VOLUME VI SEPTEMBER, 1908 NOS. 2 AND 3

PIGMENTATION SURVEY OF SCHOOL CHILDREN IN SCOTLAND.

COMMITTEE OF THE SURVEY.

Principal Sir WILLIAM TURNER, K.C.B., F.R.S., Chairman.
Professor R. W. REID, M.D., F.R.C.S.
J. GRAY, B.Sc.
J. F. TOCHER, B.Sc.

THE REPORT.

The accompanying Report which is published under the direction of the above Committee has been prepared by J. F. Tocher and consists of a Memoir on the reduced data and an Appendix. The memoir includes 72 tables, 19 diagrams and 78 maps. The Appendix contains 16 tables of classified data, and includes a list of teachers who made the Returns.

THE GRANTS.

Financial aid towards the Survey has to be acknowledged from the following sources:

			£	£
(1)	(α)	Grant by Royal Society in May 1902 .	200	
	(β)	" " " 1904 .	100	
	(γ)	" " " 1906 .	100	
		Total Grant by Royal Society . .	——	400
(2)		Grant by Carnegie Trust July 1908 . .		100
(3)		Donations by Lord Strathcona towards the payment of outlays on special sections of the work of analysis.		
(4)		The expense of printing the Appendix has been defrayed from a fund presented to this Journal in memory of W. F. R. Weldon.		

PIGMENTATION SURVEY OF SCHOOL CHILDREN IN SCOTLAND*.

By J. F. TOCHER, B.Sc.

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(1) *Introductory.*

IN 1896, the writer organized and carried out a survey of the colour characters of the school population (14,561) of East Aberdeenshire*—the first local survey of its kind in the British Isles. The cooperation of the teachers in East Aberdeenshire was so hearty that the writer conceived the idea of making a survey of the colour characters of the whole of the school population of Scotland and, afterwards, of making a survey of the physical characters of the Scottish adult population. The chief obstacle in the way of carrying out both schemes was the want of funds. At Glasgow, for instance, the British Association approved of the idea but made no Grant†. In December, 1901, however, the writer applied to the Royal Society of London for a Grant of £200, naming a Scottish Committee prepared to see the pigmentation survey carried out. The promotion of the adult survey was meantime held in abeyance. The committee named was constituted and consisted of the following: Professor, now Principal Sir William Turner, K.C.B., F.R.S., chairman; Professor R. W. Reid, M.D., F.R.C.S.; J. Gray, B.Sc., and the writer. Under the direction of this committee, the Survey was made and this Report is published. The Grant applied for was given in May 1902, and the supplementary Grants of £100 each were given in 1904 and 1906. The Royal Society has thus supplied the sum of £400 to enable the Survey to be

* Tocher, "Ethnographical Survey of School Children in Buchan," *Trans. Buchan Field Club*, Vol. IV. pp. 137—152. Observations on the colour characters of over 2800 adults belonging to the same population had already been made by the writer and his assistants in 1895 at Mintlaw in Aberdeenshire. The results of an elementary analysis of these observations together with the results of a similar analysis of measurements of adults in various parts of Aberdeenshire are embodied in joint papers by J. Gray and the writer published in the following Journals:—*Jour. Anthrop. Inst.* Vol. XXX. 1900, pp. 104—124; *B. A. Report*, 1900, pp. 193—195; *B. A. Report*, 1904, p. 707; etc.

† A Committee was formed, but no work was done, and it was dissolved in 1903, on its being pointed out that a Scottish committee with a Grant from the Royal Society was carrying out the survey.

carried out and to further the statistical portion of the work. A Donation from Lord Strathcona in November 1906 of £100 towards anthropological research on adults and children in Scotland has also to be gratefully acknowledged. A portion (£21. 10*s.*) has been expended on the work of the present Survey. The Carnegie Trust in July 1908 made a Grant of £100 in aid of publication. The total Grants in aid up to the present date thus amount to £521. 10*s.* The total cost of the Survey including outlays, for aid in statistical, clerical and other work has been £860. 1*s.* 4*d.* The writer desires gratefully to acknowledge all the Grants made, and further the aid given by Sir William Turner and Professor Reid towards securing them. Without these Grants, the Survey would not have been made.

(2) *Arrangements prior to organization.*

Immediately on receiving the Royal Society Grant of £200 in May, 1902, the writer placed himself in communication with the officials of the Educational Institute of Scotland and other teachers throughout the country. The teachers were found to be distinctly sympathetic and interested in the scheme and, by the end of December, the writer was able to report to the Committee that there was every likelihood of the teachers consenting to make the necessary observations. On the 27th December, the General Committee of Management of the Educational Institute of Scotland passed a favourable resolution communicated to the author by the secretary of the Institute in the following terms:—

COATBRIDGE, 27*th Dec.* 1902.

DEAR SIR,

I have pleasure in informing you that the General Committee of Management at their meeting to-day adopted the following motion :—"That the General Committee of Management recommend the members of the Institute to afford whatever support it may be in their power to give towards the carrying out of a pigmentation survey of school children in Scotland."

Faithfully yours,

(Signed) JOHN LAURENCE,
Sec. of the Institute.

J. F. Tocher, Esq.
Peterhead.

Thus the cooperation of the teaching profession seemed assured and every confidence was felt that the returns would be made by the teachers without any delay, after receiving the necessary schedules and instructions.

The preparation of the schedules and instructions caused the Committee much anxiety. Quite 18 months were spent in discussing the best way to have the observations made. All the leading authorities were consulted as to the numbers of categories to be employed, the reproduction of suitable colour cards, and other means of aiding the teachers in their task of determining the precise colours involved. Although in many respects desirable, the limits of this memoir preclude the author from giving more than a general statement of the decision arrived at. At the outset both Sir William Turner and Professor Reid agreed that it would be most desirable to have either standard specimens of hair and artificial eyes

properly shaded or to have colour cards if such were possible. Dr Francis Galton, Dr A. C. Haddon, Professors Macalister, K. Pearson and D. J. Cunningham were each consulted and gave valuable suggestions. Artists and lithographers were employed to reproduce the shades of colour from a very complete set of specimens of hair of all shades and from specially prepared artificial eyes. A good deal of progress was made, but on attempting to determine the various classes by aid of colour cards giving either the limits or the means of the classes, the method failed to produce satisfactory results. It was found that, compared with the results obtained by the use of samples of natural hair, observers differed seriously in the classification of colour by this method. This appeared to be due to the comparative failure of the lithographers to reproduce the natural shades required. The writer devised the following analytical table (Table I.), the range of each class being

TABLE I.

Analytical Table for Hair Colours.

<table>
<tr><td rowspan="2">RED
The hair is red; either light red, bright red, or dark red
——
All colours which approach more to red than to brown or flaxen
——
CLASS 1.</td><td colspan="3">NOT RED
The hair is not red. It is either fair, brown, or dark</td></tr>
<tr><td>FAIR
The hair is fair, that is white, flaxen, or golden-yellow only
——
{A VERY LIGHT brown may be included here}
——
CLASS 2.</td><td colspan="2">NOT FAIR
The hair is not fair. It is brown (medium) or dark</td></tr>
<tr><td></td><td>MEDIUM
The hair is chestnut brown, brownish, or is neither red, fair, nor dark
——
CLASS 3.</td><td>DARK
The hair is dark brown, or dark or black, but not jet black
CLASS 4.
——
JET BLACK ONLY
CLASS 5.</td></tr>
</table>

NOTE.—There are five divisions of hair colours recognised by the Committee.

No. 1.—The first includes all shades of red—light red, bright red, and sandy red, &c.

No. 2.—The second division includes all shades of fair, but great care must be taken *not* to include brown or medium hair. Flaxen, white, and golden yellow are the shades of fair recognised.

No. 3.—The third division includes chestnut brown, dull brown, and all shades, *not red fair, or dark.*

No. 4.—The fourth division, dark, includes very dark brown (looking black at a moderate distance), and black.

No. 5.—The fifth division is very uncommon. It is jet black

TABLE I.—(*continued*).

Analytical Table for Eye Colours.

Pure Blue	Not Pure Blue		
The eyes are pure blue	The eyes are not pure blue. They are either brown, grey, very light blue, or mixed		
Deep blue or pure blue is Class 1.	Dark	Not Dark	
	The eyes are hazel brown, dark brown, or simply dark	The eyes are not brown. They are either grey or mixed. The grey eyes may be either very light blue, light grey, or simply grey. Light grey eyes belong to Class 2, while grey and mixed belong to Class 3	
(Light blue is) Class 2.	Class 4.	Light	Medium
		The eyes are light grey, very light blue, or bluish grey.	The eyes are neither light grey, very light blue, nor bluish grey, but are either grey, greenish, orange, very light hazel, or mixed. They belong to Class 3.
		Class 2.	

Note.—There are four classes or divisions of eyes.

No. 1.—The first is the pure blue or deep blue eye which cannot be mistaken.

No. 2.—The second includes light blue and light grey eyes.

No. 3.—The third includes all eyes not blue, light grey, or brown—they are called medium eyes, and include grey, green, orange, and other mixed shades.

No. 4.—The fourth class includes hazel brown, dark brown, and dark eyes generally. The fourth class is usually spoken of as dark, and the colour appears homogeneous in character at a distance of two feet, at which distance observations ought to be made.

In noting the colour of the eyes, first note whether they are blue or brown. If these are excluded note whether they are grey. If light grey, they are light eyes, if grey, they are medium eyes. If the eyes are neither blue (1), grey (3), nor brown (4) they are either light eyes (2) or medium eyes (3) [of which grey, previously mentioned, is only one shade]. Light eyes having been already excluded, they are medium or mixed eyes. *It is best to call up a few children at a time and judge by comparison.*

fully described. In making colour observations, each class in this table is determinable by the observer by a process of elimination of the other classes. The results obtained by the use of this table were now compared with the results obtained by using samples of hair, for hair colour, and of glass eyes, for eye colour and also with the results, for eye colour, obtained from observations on boys and girls selected as types of each class. It was found that both sets of figures closely agreed, and the results were therefore considered very satisfactory. The colour card method

Pigmentation Survey of School Children in Scotland.

Name of School..... *Parish*..... *County*..... *District No.*.....

Name of Teacher..... *Date of Survey*.....

Sex of List of Children on this Sheet.....

(Boys or Girls).

*** *To save trouble to yourself, number the whole school consecutively from 1 onwards, after the names have been entered from Register and before noting the colours.*

INDICATE COLOUR OF HAIR AND EYES by an X in Corresponding Column

No.	AGE.	HAIR.					EYES				SURNAME.	RELATIONSHIPS. Use this column to indicate relationships in any manner you please if you do not use the next column. If you use the next column, ignore this one.
		Fair	Red	Med	Dark	Jet Black	Pure Blue	Light	Med	Dark		

was then reluctantly abandoned and the analytical table with broad classes was adopted as one likely to lead to the least error in determining the colour characters of the children. The accompanying schedule (Table II., much reduced size) was adopted by the Committee, the table (Table I.) with the description of the classes being printed on the back of each schedule.

The form of schedule and descriptive analytical table being definitely settled the author drew up a circular letter to the teachers which was adopted by the Committee*.

Mr John Gray's name was, with the consent of the Committee, associated with the writer's in the circular, as it had been mutually arranged that, after the data had been collected and summarised by the author, a joint paper should be prepared. This idea was departed from, at a later date, at Mr Gray's suggestion. With the Committee's approval he has, instead, written a short memoir illustrating his method of dealing with the observations grouped into districts, from Tables XI., XII., XIII. and XIV. of Appendix supplied to him by the writer who, on completing the statistical analysis, gladly supplied Mr Gray with the tables referred to†. District grouping suited the purpose he had in view of representing, by contour lines, the imaginary up and down steps by which he assumes one locality gradually to merge in intensity of colour into adjacent ones. The

7 *December* 1903.

*DEAR SIR, OR MADAM,

As you may have seen reported, this Committee proposes, with your kind assistance, to carry out a survey of the colour characteristics of the school children of Scotland.

We beg to enclose the necessary form, and we should feel very much obliged if you will kindly record the names and colour characteristics of the children of your school for the use of the above Committee.

The purpose of this survey of the colour characteristics of the children is to collect statistics in order to elucidate racial characters, the laws of heredity, and the general problem of evolution.

The Committee suggests that, when convenient, the teacher in charge of each class should first have the names and ages, and if possible the relationships, of the children recorded in the sheets. After this has been completed, he or she could then, at convenient times, call up the children, five or six at a time, and note the colour of the hair and the colour of the eyes, following the instructions on the analytical table on the back of each observation sheet.

We may briefly mention that in carrying out this Survey, besides the private goodwill of hundreds of Teachers, the General Committee of Management of the Educational Institute of Scotland support the idea. The following resolution of the General Committee was adopted in December last:—

"That the G.C.M. recommend the Members of the Institute to afford whatever support it may be in their power to give towards the carrying out of a Pigmentation Survey of School Children in Scotland."

The Royal Society is aiding the survey by a grant from the Government Funds, while the results, besides being published in scientific journals, will be printed as a separate memoir. This memoir will contain a complete list of the contributing teachers and of the statistics forwarded from each school. We have provided for the survey of over 750,000 children, which is the estimated number in Scotland.

We sincerely trust you will, without inconvenience to yourself, supply the Committee early with the particulars asked, and do what you have in your power to assist in a survey which has such a high bearing on the racial characters of the Scottish people.

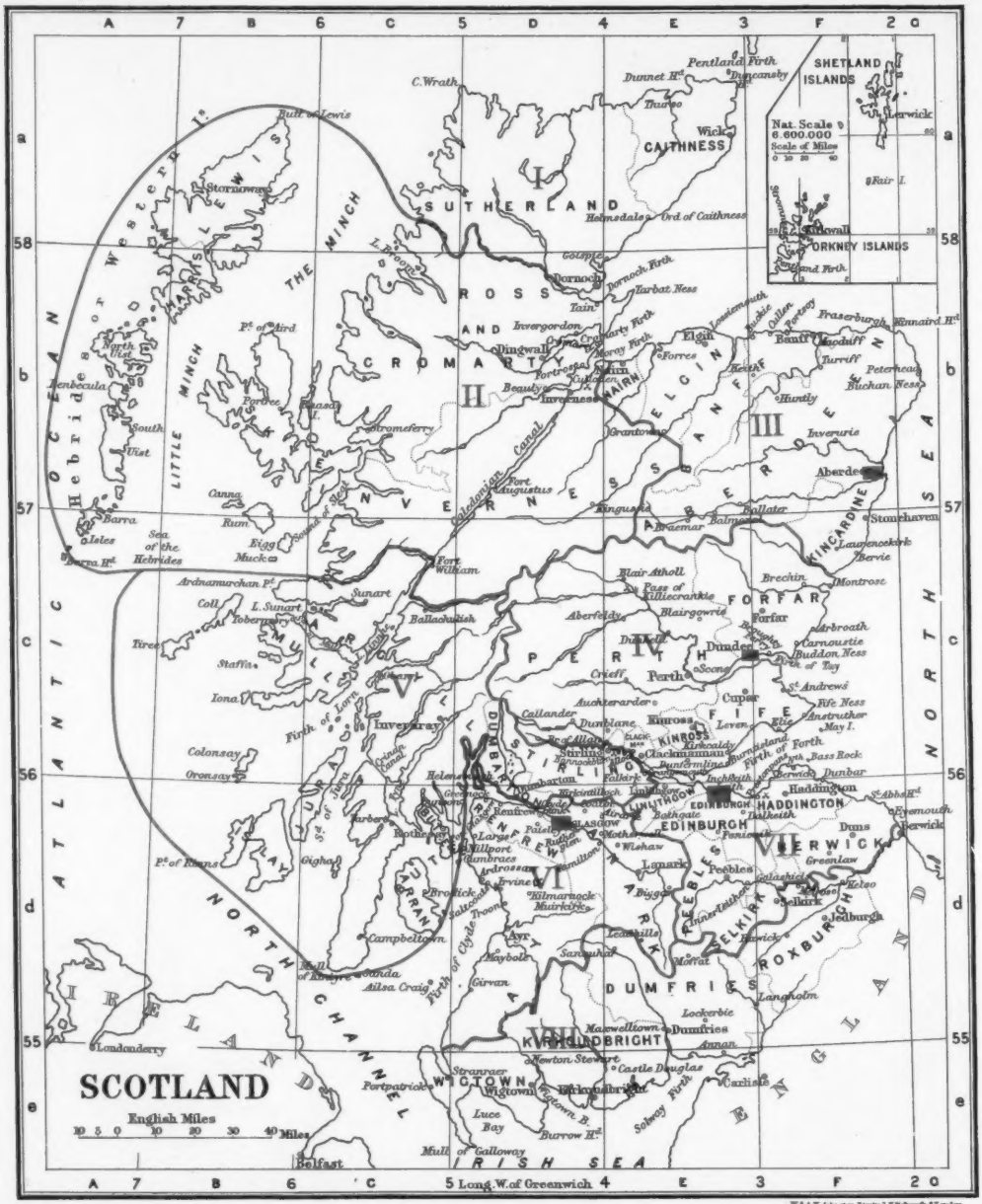
† These tables as supplied to Mr Gray do not, of course, contain the figures from the late Returns.

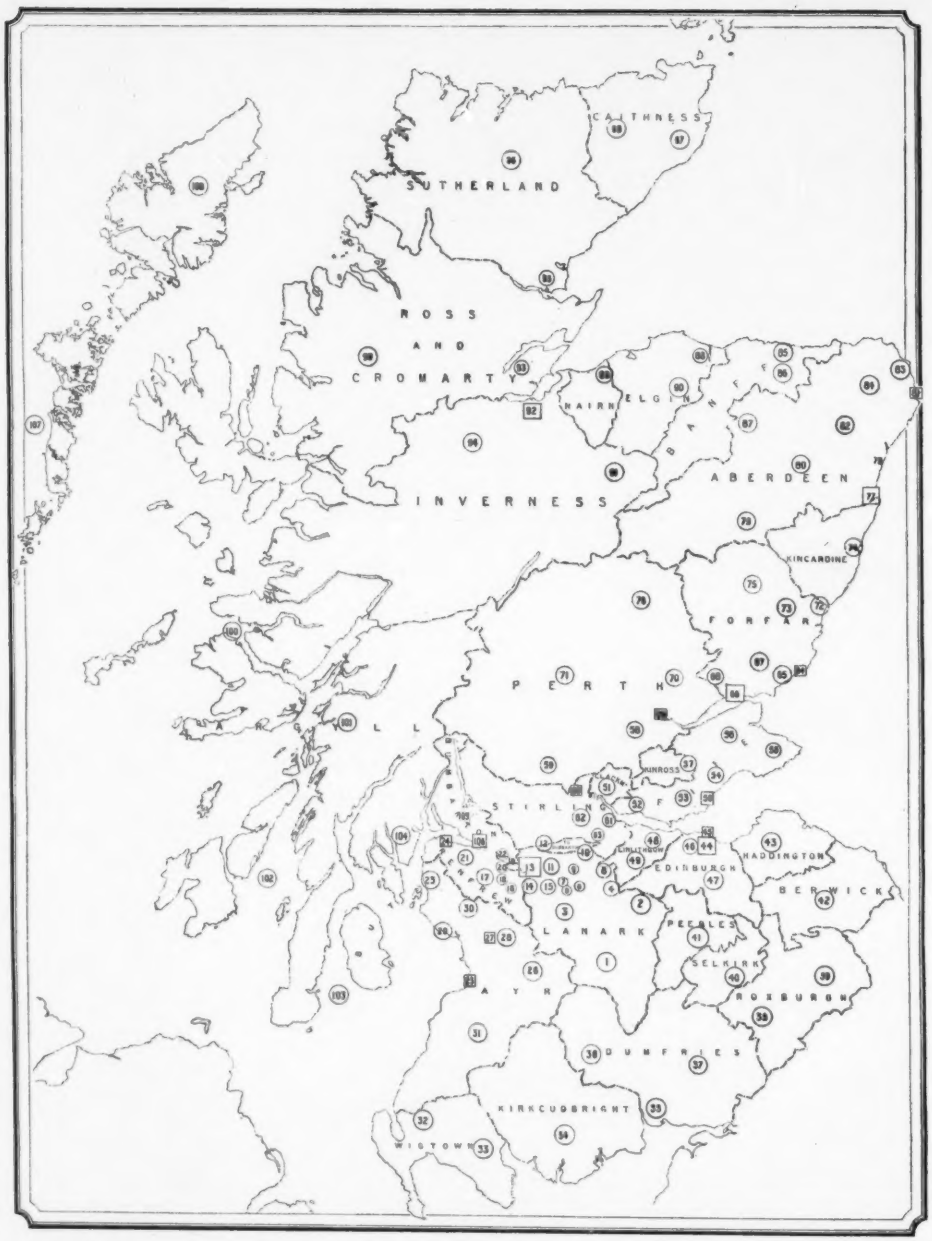
reader is referred to Mr Gray's paper for details as to this system of representation of intensity of colour. The author has to acknowledge his indebtedness to Mr Gray for the help he gave in the construction of the schedule and to thank him cordially for such cooperation as he was able to give otherwise. Owing to his residence in London, Mr Gray was unable to take part either in the actual work of organizing and carrying out of the survey, or in the laborious and prolonged statistical analysis after the survey had been completed. The writer, however, received great assistance from his own clerical staff, the members of which worked frequently at high pressure to a late hour, in order to have the work completed within a reasonable limit of time.

(3) *Organization and carrying out of the Survey.*

The colour classes, schedules and other forms being approved of by the Committee, the next step to be considered was their issue to the teachers. A reference to the Appendix to the Annual Report* issued by the Scotch Education Department showed that in 1902 there were 3145 schools in the 33 counties of Scotland with an actual average attendance of 646,501 scholars. It was further noted, that, including principals, there were 11,638 certificated teachers giving instruction to these children, and who, on the suggestion of the principals, might be willing to take part in the voluntary task of noting the colour characters of the children and recording them, together with the other information desired, on the forms supplied. It was recognised from the outset that while many principals would be quite willing to survey the whole school in each case, this would be a task of great magnitude in the larger schools, where the average attendance reached several hundreds and in many cases considerably over a thousand. The average number to be examined in each school, on the assumption that each head master or mistress made the observations, amounted to 205 children; while if every certificated teacher took part, the number was reduced to 55. It was seen that there would be great deviations in excess of these averages and therefore it was considered eminently advisable, if the survey was to be a success, that the certificated teachers generally should be invited to take part. This, it will be seen presently, was done through the medium of the principals, with the most fruitful results from both principal and class teacher. The schools from which it was considered desirable to receive returns of observations on the colour characters of the children, were those aided by Parliamentary Grants. The complete list of these schools receiving such grants for the twelve months ending the 31st August, 1902, is given in the Appendix to the Report already referred to, and this list formed the basis of the author's operations in carrying out the survey. As was originally the design of the author, he arranged to classify the returns in the usual and well-known basis of parishes and counties, and also into groups intermediate on an average in magnitude between parishes and counties. As will

* Report of the Committee of Council on Education in Scotland, with Appendix, 1902—1903. Appendix, Part II. Table 3, pp. 488—651.


SCOTLAND
English Miles
10 5 0 10 20 30 40 Miles
Long. W. of Greenwich
SHETLAND ISLANDS
Nat. Scale 6.600.000
Scale of Miles
ORKNEY ISLANDS
CAITHNESS
SUTHERLAND
ROSS AND CROMARTY
INVERNESS
NAIRN
MORAY
BANFF
ABERDEEN
KINCARDINE
FORFAR
PERTH
FIFE
KINROSS
CLACKMANNAN
STIRLING
DUNBARTON
ARGYLL
BUTE
LINLITHGOW
EDINBURGH
HADDINGTON
BERWICK
PEEBLES
SELKIRK
ROXBURGH
DUMFRIES
KIRKCUDBRIGHT
WIGTOWN
Hebrides or Western Isles
ATLANTIC OCEAN
NORTH SEA
NORTH CHANNEL
IRISH SEA
ENGLAND
IRELAND
Pentland Firth
Dunnet Hd
C. Wrath
Butt of Lewis
Stornoway
Wick
Duncansby Hd
Tarbet Ness
Dornoch
Tain
Cromarty Firth
Inverness
Fort Augustus
Caledonian Canal
Loch Ness
Fort William
Ballachulish
Glencoe
Oban
Inveraray
Loch Awe
Loch Lomond
Dumbarton
Glasgow
Paisley
Greenock
Ayr
Girvan
Stranraer
Portpatrick
Wigtown
Newton Stewart
Castle Douglas
Dumfries
Lockerbie
Annan
Carlisle
Solway Firth
Luce Bay
Burrow Hd
Mull of Galloway
Belfast
Londonderry
Aberdeen
Stonehaven
Montrose
Arbroath
Dundee
Perth
Forfar
Brechin
Blairgowrie
Pitlochry
Aberfeldy
Crieff
Auchterarder
Cupar
St Andrews
Anstruther
Leven
Kirkcaldy
Dunfermline
Queensferry
Bass Rock
North Berwick
Dunbar
Haddington
Musselburgh
Portobello
Leith
Edinburgh
Dalkeith
Peebles
Galashiels
Selkirk
Kelso
Jedburgh
Hawick
Berwick
Lanark
Biggar
Moffat
Langholm
Lochmaben
Dumfries
Kirkcudbright
Wigtown
Ayr
Girvan
Maybole
Campbeltown
Ailsa Craig
Mull of Kintyre
Islay
Jura
Colonsay
Oronsay
Iona
Tiree
Coll
Barra
Lewis
Harris
North Uist
South Uist
Benbecula
Skye
Raasay
Rum
Eigg
Muck
Canna
Sea of the Hebrides
Little Minch
The Minch
Sound of Harris
Sound of Jura
Firth of Lorn
Firth of Clyde
Firth of Forth
Firth of Tay
Moray Firth
Beauly Firth
Dornoch Firth
Kyle of Sutherland
Pentland Firth
Orkney Islands
Shetland Islands
Fair I.
Sumburgh Hd
Kirkwall
Stromness
Scapa Flow
Inverness
Nairn
Elgin
Forres
Banff
Macduff
Fraserburgh
Peterhead
Buchan Ness
Inverurie
Huntly
Braemar
Ballater
Kingussie
Grantown
Aviemore
Carrbridge
Tomatin
Beauly
Dingwall
Invergordon
Tarbet Ness
Helmsdale
Ord of Caithness
Thurso
Duncansby Hd
Kirkwall
Wick
Lerwick
Fair I.
Sumburgh Hd
Pt of Ayre
Pt of Rhins
Mull of Kintyre
Pt of Bird
Pt of Barra
Barra Hd
Ardnamurchan Pt
Sunart
L. Sunart
Tobermory
Staffa
Iona
Colonsay
Oronsay
Islay
Jura
Gigha
Arran
Brodick
Lamlash
Campbeltown
Ailsa Craig
Girvan
Maybole
Ayr
Troon
Irvine
Kilmarnock
Muirkirk
Hamilton
Motherwell
Wishaw
Coatbridge
Airdrie
Cumbernauld
Kirkintilloch
Bishopbriggs
Milngavie
Renfrew
Greenock
Port Glasgow
Helensburgh
Rothesay
Largs
Millport
Dunoon
Inveraray
Loch Awe
Loch Lomond
Loch Katrine
Loch Tay
Loch Rannoch
Loch Ericht
Loch Laggan
Loch Lochy
Loch Arkaig
Loch Shiel
Loch Eil
Loch Linnhe
Loch Leven
Loch Etive
Loch Fyne
Loch Long
Loch Goil
Loch Striven
Loch Ryan
Loch Indaal
Loch Gruinart
Loch Skipport
Loch Boisdale
Loch Maddy
Loch Carnan
Loch Roag
Loch Seaforth
Loch Erisort
Loch Resort
Loch Tarbert
Loch Snizort
Loch Portree
Loch Sligachan
Loch Harport
Loch Dunvegan
Loch Bracadale
Loch Eynort
Loch Uskavagh
Loch Boisdale
Loch Eynort
Loch Skiport
Loch Carnan
Loch Maddy
Loch Roag
Loch Seaforth
Loch Erisort
Loch Resort
Loch Tarbert
Loch Snizort
Loch Portree
Loch Sligachan
Loch Harport
Loch Dunvegan
Loch Bracadale
Loch Eynort
Loch Uskavagh
W. & A. K. Johnston, Limited, Edinburgh & London


CAITHNESS
SUTHERLAND
ROSS
AND
CROMARTY
NAIRN
ELGIN
BANFF
ABERDEEN
INVERNESS
KINCARDINE
FORFAR
PERTH
KINROSS
STIRLING
HADDINGTON
EDINBURGH
BERWICK
PEEBLES
LANARK
SELKIRK
ROXBURGH
AYR
DUMFRIES
KIRKCUDBRIGHT
WIGTOWN

be seen later, these two methods were adopted by the Committee and employed by the author as convenient and desirable ones for the purpose of analysis. At this stage, however, Mr John-Gray suggested "the natural subdivision of the country into river basins, as it is well known that watersheds, when they form mountain ranges even of moderate size act as racial barriers." The view was expressed by him that "if the ordinary subdivision into counties were adopted, we should have in many cases to include populations with quite different characteristics in the same division and valuable ethnic distinctions would be lost in taking an average." The suggestion seemed a good one as a means of determining the differences between the populations in the various river basins. Also, when the population in each river basin is subdivided into districts, we have the means of determining whether any one district significantly differs from another in that basin. But this method of grouping is neither superior nor inferior to any other method of grouping populations in adjacent areas, as all that can be said in each case is that, conformably to size of sample, the population differs or does not differ from another population or from the general population of the country. Thus counties and groups of counties are quite convenient groups for the statistician to deal with, and since this method of grouping is well known to the public, it has a slight advantage over any other. Again, one must remember that no one method of grouping will solve all the problems the anthropometrician desires to solve. For instance, one may wish to contrast a city population with its environs; a mining population with a rural one; or a coast population with an adjacent inland population. Thus special groupings are frequently necessary.

In a small country like Scotland the river basins are exceedingly small, compared with the great basins on the continents of Europe, Asia, Africa and America. Besides, one has in Scotland a population the vast majority of the members of which speak one language and which has bred intraracially for generations. It therefore did not seem to the writer to be likely that grouping by river basins alone would yield all the information obtainable as to the distribution of colour, but the general idea of basins was kept in view in constituting the groups intermediate between parishes and counties, namely, districts. Thus a satisfactory solution of the area problem was found, since all the groupings discussed, namely schools, parishes, districts, counties and river basins, were and are available for statistical analysis.

The writer proceeded to carry out the district* system of grouping, commencing with the county of Lanark. Altogether 110 districts were thus constituted, the task of locating schools on the maps being an exceedingly laborious one indeed, so that much time was consumed in the construction of the districts. The Key maps opposite page 137 (Maps I.† and II.) show in a general way the

* The special district grouping has been used by the writer to determine urban, suburban and rural differences and, as already stated, is the basis of Mr Gray's memoir. Of course the maps constructed by him show the districts graded and do not show the actual numerical district averages as given in tables supplied to him.

† For names of the Divisions see Explanatory Note, p. 148.

location of these districts, while their exact relationship to counties is given in the following table (Table III.).

TABLE III.

Counties (with Districts).

Aberdeen, 77, 78, 79, 80, 81, 82, 83, 84, 86, 87. Argyll, 100, 101, 102, 103, 104. Ayr, 23, 25, 26, 27, 28, 29, 30, 31, 32, 33, 36. Banff, 85, 86, 87, 90, 91. Berwick, 39, 42. Bute, 103, 104. Caithness, 97, 98. Clackmannan, 51. Dumbarton, 10, 12, 19, 22, 101, 105, 106. Dumfries, 35, 36, 37. Edinburgh, 44, 45, 46, 47. Elgin, 88, 89, 90, 91. Fife, 50, 52, 53, 54, 55, 56, 57. Forfar, 64, 65, 66, 67, 68, 72, 73, 75, 76. Haddington, 43. Inverness, 89, 91, 92, 93, 94, 99, 100, 107, 108. Kincardine, 72, 73, 74, 75, 79. Kinross, 57. Kirkcudbright, 33, 34, 36. Lanark, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15. Linlithgow, 48, 49. Orkney, 109, 110. Nairn, 89, 90. Peebles, 41. Perth, 51, 57, 58, 59, 68, 69, 70, 71, 76. Renfrew, 14, 16, 17, 18, 19, 20, 21, 23, 24. Ross and Cromarty, 93, 95, 96, 99, 108. Roxburgh, 37, 38, 39. Selkirk, 38, 40. Shetland, 110. Stirling, 10, 12, 59, 60, 61, 62, 63. Sutherland, 95, 96. Wigtown, 32, 33.

This completed the work of organization, and the writer at once proceeded to carry out the survey. On the afternoon of the 7th December, 1903, the schedules, with instructions, leaflets stating fully the object of the survey, circular letters to teachers and addressed return envelopes* were sent out from Peterhead to 3329† different school establishments in Scotland. At the same time an explanatory letter, setting out the objects of the survey, and the nature of the results expected to flow from the data about to be collected, was sent to all the leading daily and weekly newspapers in the country. Public attention was thus at once directed to the scheme approved of and circulated by a Committee which had for two of its members Professor (now Principal) Sir Wm. Turner, and Professor R. W. Reid, well known University teachers, and notable for their contributions in the domain of anatomical and anthropological science. The fact of having two such experienced and distinguished men associated with the survey, actively promoting it and directly recommending it to the teachers, has meant everything to the success of the undertaking, and has translated it from a desirable and important scheme on paper to an accomplished fact. The author can never sufficiently thank Sir Wm. Turner and Professor Reid for their solid backing of the survey, their hearty cooperation during the entire period from its inception until now, and for their uniform courtesy and kindness during the entire course of the many interviews the author has had with each. The proposed survey was widely noticed by the daily press, was favourably commented on and strongly recommended to the notice of the teachers.

* These envelopes were addressed to 36, York Place, Edinburgh, when by arrangement with the Post Office, they were, as received, immediately sent on to Peterhead. The writer's examining work took him frequently to Edinburgh and permitted of this arrangement being carried out. On his own behalf and that of the Committee he has cordially to thank Mr J. Rutherford Hill and his staff for providing a collecting centre for the Returns and for the trouble and care taken in sending them on to their present resting place.

† This was the apparent number of schools at the time. Several of these were afterwards found to be merged in other schools while a few were found to be extinct.

Meantime, in order to have the returns systematically arranged for inspection and tabling, two large cases (9′ × 7′) having 120 compartments were made ready and put in the writer's laboratory. Of the compartments, 110 were prepared for the special reception of the returns by districts, but of course each return envelope had printed and written on it the name of the school, parish, district and county to which it referred, for immediate identification. The remaining compartments were reserved for incomplete returns. A special case with county compartments was prepared to deal with the separate correspondence and a series of despatch boxes was obtained to hold and systematise the tabled data. These, with a typewriter, constituted the equipment for the survey. Everything was now ready for action.

On the 8th December, one day after the issue of the schedules, the first group of returns—5 in number—was received. After this a steady flow of returns came by each post. Within a fortnight, 366 had been received, and by the beginning of the last week of December the author was able to submit his first Interim Report to the Royal Society, stating that over 700 had been returned. Hundreds of letters had meantime been received asking for additional schedules and for explanation as to what appeared doubtful to the teachers making enquiries. These were all promptly answered, and as a result of the experience gained with those returns already sent in, an additional explanatory circular was sent out to those schools from which returns had not yet been made. This circular made clear doubtful points with regard to (1) classification of boys and girls, and (2) the method of recording relationships. The circular had the desired effect of obviating any further difficulties in making the observations. A steady stream of returns came during the early months of the year 1904. Each return was at once acknowledged and the teacher making the return thanked on behalf of the Committee. The response of the teachers was remarkable. The vast majority of them made the returns in an evidently painstaking and careful manner; and a great many of them, besides, wrote explanatory letters as to relationships, ancestry and probable racial mixture of their groups. The author was kept employed acknowledging these, and in replying to the hundreds of additional letters of enquiry during the first nine months of the year. In order to keep the scheme fully before the teachers, a reminder circular was issued in April to those schools from which no returns or acknowledgments had been received. This had the effect of bringing in a larger proportion of returns during the month of April. The rate steadily decreased until November, when only 3—the last included in the analysis—came in by post and were acknowledged. The following table (Table IV.) shows the actual numbers received during each month and the rate of return per cent. per month.

Altogether, 2695 returns were however received, but of these 407 were incomplete in certain particulars. Over 500 schools therefore made no return. The following table shows only the number of schools from which complete returns were received. With regard to the incomplete ones, either the names, ages, sex or

TABLE IV.

Table of Returns Received.

Year	Month	Number received	Per cent.
1903	December	817	35·71
1904	January	548	23·95
„	February	344	15·04
„	March	146	6·38
„	April	270	11·80
„	May	84	3·67
„	June	22	·96
„	July	22	·96
„	August	25	1·09
„	September	5	·22
„	October	2	·09
„	November	3	·13
Totals	—	2288	100·00

colour characters singly or jointly with one another were wanting. These schools have not been dealt with in this memoir. The data proper therefore consisted of fully complete returns from 2288 schools containing the records of the names, ages, sex, fraternal and cousin relationships, and colour characters of 257,766 boys and 244,389 girls, a total of 502,155 children. Although there was a good deal of further correspondence with the teachers, only a few more returns were received after November, 1904. These have not been included in the district analysis which was in operation before the returns were received but have been included in the division, county and general analyses*. The work of classification and tabling, which was commenced as soon as practicable, was soon in full operation. The response of the teachers had been remarkably enthusiastic and complete. The survey was an accomplished fact.

On behalf of the Committee the writer begs to acknowledge its great obligations to the teaching profession in Scotland for so promptly responding to the invitation of the Committee to carry out the desired observations. The writer also wishes to record his *personal* sense of indebtedness to the teachers and to thank them very cordially for all the pains and trouble they have taken in making the elaborate returns so vital to the success of the scheme. The credit of the accomplished survey is undoubtedly due to the teachers. Without the recognition

* The late returns came from the counties of Lanark, Renfrew, Banff, Elgin and Inverness and belonged, in the district scheme, to the first, fourth, eighteenth and ninety-first districts. The total results of observations for these districts are however given in the Appendix tables and not the slightly smaller figures on which the district analysis was made. The figures for the later returns are also of course given along with the others under their respective parishes and counties and were included in all analyses except the district one. The only points therefore to be noted are (1) that the district analysis is based on the slightly smaller general totals and (2) that, in the analysis of Districts I., IV., XVIII. and XCI., the late returns (not to hand at the time of analysis) are excluded.

by them of the importance of this scientific investigation, their cordial cooperation and most painstaking and laborious setting down of all the minute details required from each school, the survey would have been still in the limbo of fancy, to remain there until the census office should have the power to deal with the matter, along with the present ordinary details of this important statistical department. Only when the recording of measurable and non-measurable characters comes to be included in the census, and is dealt with officially, will the importance of much voluntary pioneer work by the teaching profession be fully recognised.

(4) *The Problems to be discussed.*

Before proceeding to make a brief statement of the analytical methods employed and to follow with a general discussion of the resulting classified data, it seems desirable at this stage to enumerate the problems germane to the survey.

(*a*) The first problem clearly is: How are the children distributed with respect to the various colour classes, what is the proportion of children found in each class, and how does the general distribution among the classes compare with those of the continental countries already surveyed?

The answer to this problem is given (α) in Table XIII., where the general distribution and the percentages of the colour classes are given, and (β) in section (12), where the results are compared with those of continental countries.

(*b*) The second problem deals with relative local differences in each colour class. Considering each colour class or category separately, one must ask, by how much does each locality in Scotland (division, county or district) differ from the remaining population? In other words, is the distribution of colour uniform throughout Scotland, and if not by how much does the proportion for each class in each locality differ from the proportion which would occur on an even distribution of the school population over the whole country? This amount when found for each locality is termed the relative local difference and the complete solution of the problem is reached when significant relative local differences are determined, and separated from those relative local differences which are fair samples of the general population. This problem is dealt with under section (6).

(*c*) The third problem is one bearing on the general resemblance of local populations to the general population. Here hair colour as a character is considered as a whole in each locality, all the classes constituting the character being considered together. Similarly eye colour as a character is considered as a whole in each locality. The distribution in each locality of the classes constituting each character is compared with the corresponding general distribution of the classes for the same characters which is found for the whole country. Considering, in this manner, hair colour collectively or eye colour collectively, do or do not local populations resemble the general population? If local populations do not resemble the general population how far do the actual local frequencies as a whole differ from the corresponding frequencies which would occur on an even distribu-

tion of the population throughout the country? In other words, if divergencies from this even distribution occur, what is the relative degree of divergency for each locality? This is, in short, the third problem which is discussed in section (7).

(*d*) The degree of local segregation of each of the colour classes constitutes the fourth problem. If the population is not evenly distributed with respect to the colour classes, which class shows the greatest degree of isolation into separate groups? This can be determined by considering successively the nature of the distribution of relative local differences of each class collectively and without reference as to where each local difference occurs. That is to say the relative local differences of each class are successively considered interlocally as a whole and the variability of each distribution determined. The greater the variability of the distribution of relative local differences for a class the more uneven will be the distribution of the class throughout the country, and the greater will be its massing into groups, and thus the greater will be the local segregation of the class. This problem is considered in section (8).

(*e*) It is important from the eugenic standpoint to know whether pigmentation is associated in any way with disease, inherited or non-inherited defects, race, or with density, fertility or other characters of the population. These problems are considered in section (9).

(*f*) An interesting problem which is concerned with sexual differences is considered under section (10). The problem may be divided up into three parts. 1. In what respects, if in any, do the constants found for boys and girls differ? 2. Are there any significant pigmentation differences between boys and girls? 3. What is the average resemblance between the male and female factors of the population?

(*g*) The next problem is one concerning urban and suburban populations. The questions may be put. 1. Are there any significant differences between the purely urban and the suburban and rural populations, and if so in what respects do they differ? 2. What differences occur (α) within each urban population (*i.e.* intralocally), and (β) between different urban populations (*i.e.* interlocally), and are these differences environmental, racial or both? This problem is dealt with in section (11) with special reference to Glasgow and its environs.

(*h*) A further problem which is of importance turns on the point as to whether hair and eye colours are independent variables or whether they are dependent. It is desirable therefore to know what degree of association, if any, exists between hair and eye colours. If association is found to exist does the relationship found agree or differ with that indicated by former surveys of adults and children. This problem is considered among others in section (12).

(*i*) The pigmentation data present other problems for solution, such as whether brothers and sisters or cousins resemble one another to any degree in hair and eye colour. These problems are not dealt with in this memoir.

(5) *Methods Employed to Determine Significant Differences.*

In making a survey of the measurable physical characters of a population one has not only to ascertain the type and variability of each character but also to consider the relationship of each local group to the general population*. Thus, in the recent investigation on the inmates of asylums it is shown that several physical types exist among the Scottish insane, and that, whether they differ or not from the sane population, local asylum groups generally do not resemble the general insane population. But non-measurable characters can scarcely yet be dealt with in the same way. It has not been found possible up to the present time, for instance, to determine the value of the character, hair colour, just because no quantitative scale based on experience has yet been devised on which to plot the observations in an orderly way indicating increase or decrease of intensity of colour. It is not clear whether such a scale is possible. Experimental work has just been undertaken by the writer which may throw some light on this point. But while hair colour cannot yet be represented on a scale of intensity of colour such as stature or head length, it can be quite properly dealt with under well defined classes or categories. As already explained, the limits of these classes have been defined in the analytical table given in each schedule. What statisticians have here to consider therefore are the frequencies of the various classes individually and collectively without reference as to whether the classes can be arranged on a scale showing grades of intensity of colour. This has been done on a moderate scale for adults†, and it may be well to restate here the methods employed before proceeding to state the results of the analysis.

A population of N individuals is to be considered, each of which possesses the character X. The character X is not measurable but can be divided into m classes. Let $s_1\ s_2 \dots s_m$ be the classes and let the class frequencies for the whole population be respectively $y_{s_1},\ y_{s_2} \dots y_{s_m}$. The population is divided into groups of magnitude n, and each group is observed and classed with respect to the character X. In making the observations, the probability that any person observed (if the operation is a random one) belongs to class s is $y_s/N = p$, and the probability of the person not belonging to that class, but to one of the others is $(1-p) = q$. If the groups are samples drawn from the general population purely at random, the frequency for the class s for each of the groups is therefore equal to $ny_s/N = np = y_s'$, which is thus for the class s the most probable number likely to be drawn in this way; or is, shortly, the theoretical class frequency. It is necessary to consider what would happen if the whole population was observed in unselected groups at random for the following reason. If the observed class frequencies in the various geographical areas actually differed insignificantly from the theoretical class frequencies then it would be clear that the population was evenly distributed with respect to the character. Thus, *so far as this character is*

* Tocher: *Biometrika*, Vol. v. Part III. pp. 315 et seq.

† Tocher: *Biometrika*, Vol. v. Part III. pp. 335 et seq.

concerned, it would be a homogeneous population. Heterogeneity must be sought for in other characters. If all the physical characters showed homogeneity then it would be clear that one had a common race to deal with. But if, with respect to the character X, the observed and theoretical class frequencies appeared to differ significantly, then the population would not be evenly distributed with respect to X. Instead, there would be excess frequencies in some classes and frequencies falling quite short of theory (*i.e.* the proportional even distribution) in others in various localities or groups. One would then have to ascertain whether the significant differences were racial or due to other influences. The question now is: How can one determine whether any difference between observation and theory is significant or not? In other words, if $y_s'' =$ observed class frequency, how can one measure the significance of $y_s'' - y_s'$? Pearson* has pointed out that the distribution of such differences as $y_s'' - y_s'$, if occurring at random, takes the form of the hypergeometrical series

$$M\frac{pN(pN-1)\ldots(pN-n+1)}{N(N-1)\ldots(N-n+1)}\left\{1+n\frac{qN}{pN-n+1}+\frac{n(n-1)}{1.2}\frac{qN(qN-1)}{(pN-n+1)(pN-n+2)}+\ldots\right\},$$

and he has shown that the standard deviation of the distribution is given by

$$\Sigma_{(y_s''-y_s')}=\sqrt{npq\left(1-\frac{n-1}{N-1}\right)}.$$

The areas on either side of the ordinate which divides the distribution at the abscissal value $(y_s''-y_s')/\sqrt{npq(N-n)/(N-1)}$, are proportional to the probabilities of greater or lesser values than the particular value found occurring in future samples. The areas can be determined when the form of curve is known. In the great majority of cases in this survey, the values of n although fairly large are but small fractions of N, and p is not very small. In such cases the hypergeometrical distribution closely approximates the normal curve, the constants β_1 and β_2 being respectively 0 and 3 within the limits of their probable errors. The modal value of the distribution is the nearest whole integer to $\frac{(qN+1)(n+1)}{N+2}$, which differs insignificantly from the mean, nq. Thus the asymmetry and leptokurtosis are insignificant and therefore the probability of greater or lesser values than that found occurring in future samples can be determined from the tables of the probability integral. In certain cases the fraction $\frac{n}{N}$ is an appreciable one, and in these the asymmetry and leptokurtosis are both significant.

In certain other cases p is rather small. In these cases the interpretation of the value of the standard deviation given, which in itself is correct, requires considerable modification because the hypergeometrical series can be no longer

* Pearson: *Biometrika*, Vol. v. pp. 173—175.

satisfactorily represented by the normal curve. The tables of the probability integral are therefore not applicable and do not give the probabilities. They can be found however when the type and the constants of the curve which fits the hypergeometrical distribution have been determined. Tables* for these extreme cases are in the course of production, but they involve laborious calculation and it may be some time before they are ready. Accordingly special stress must not be laid on the differences found where the value of p is such as to give a significantly asymmetrical distribution of samples from which the probabilities of greater or lesser values in future samples are found.

The form in which each difference has been expressed and studied requires notice. It is obvious that, in considering differences and their standard deviations, one may take the observed absolute numbers and expected absolute values—that is, in the notation herein used, y_s'' and y_s'. Again one could take the observed and theoretical percentages—that is the difference $100\{(y_s''/n)-p\}$; or reckoning y_s' in each case as 100, one could take the difference as $100\{(y_s''/y_s')-1\}$. Now it is easy to see that $\sqrt{npq(N-n)/(N-1)}$, reckoned as a percentage, is $100\sqrt{pq(N-n)/n(N-1)}$, the standard deviation with which $100\{(y_s''/n)-p\}$ has to be compared. Expressed as a coefficient of variation, it is also easily seen to be $100\sqrt{q(N-n)/np(N-1)}$, the variability constant (decreasing as n increases) with which $100\{(y_s''/y_s')-1\}$ has to be compared. Thus there are for selection, according to convenience, in the statistical analysis, the three ratios

$$(1)\quad (y_s''-y_s')/\sqrt{npq(N-n)/(N-1)}.$$

$$(2)\quad 100\{(y_s''/n)-p\}/\sqrt{100^2pq(N-n)/n(N-1)}.$$

$$(3)\quad 100\{(y_s''/y_s')-1\}/100\sqrt{q(N-n)/np(N-1)}.$$

It is perfectly obvious that the above ratios, applied to the data, will give identical results. These ratios will, throughout this memoir, be called *relative local differences* (*RLD*), this term being the one introduced by the writer in a previous investigation to denote the local differences in the physical characters of the Scottish insane†. In determining relative local differences, the first expression, which deals with the absolute figures, has been the one used, the calculations having been performed in duplicate. Since the percentages in district groups have been calculated, it was found convenient to use the second form in cases where it was necessary to compare certain of these districts with the general population.

The following table (Table V.) constructed to illustrate, by means of maps, the relative local differences in the physical characters of the Scottish insane† will be used throughout the memoir both in the text and in the maps, and defines the terms used to indicate the significance or non-significance of the observed results. From what has already been said, these relative local differences when n is fairly

* *Biometrika*, Vol. v. p. 175.

† Tocher: *Biometrika*, Vol. v. Part III. pp. 317—318; also Table VIII. of that memoir.

TABLE V.

Class Ranges.

The value found compared with the value for the general population is	Specific Term	Class	*RLD.* Range of Class in terms of $(y_s'' - y_s')/\Sigma(y_s'' - y_s')$
Very much smaller	Distinctly Micrometropic	−4	−3·5 upwards
Probably significantly less	Probably Micrometropic	−3	−2·5 to −3·5
Less but not quite significantly less	Mesometropic	−2	−1·5 to −2·5
Very slightly less	Mesometropic	−1	−0·5 to −1·5
Quite insignificantly different	Mesometropic	0	0·5 to −0·5
Very slightly greater	Mesometropic	1	0·5 to 1·5
Greater but not quite significantly greater ...	Mesometropic	2	1·5 to 2·5
Probably significantly greater	Probably Megalometropic	3	2·5 to 3·5
Very much greater	Distinctly Megalometropic	4	3·5 upwards

large, but small compared with N and p is not very small, are evidently the abscissal values of the normal curve whose equation is

$$y = \frac{1}{\sqrt{2\pi}} e^{-\frac{x^2}{2}}.$$

These conditions exist for the majority of cases, and here therefore, for any individual result, the probabilities of greater or lesser values can be readily calculated. But in cases where asymmetrical curves result owing to n/N being appreciable, or p small or both, the probabilities, as already stated, cannot be found from the tables of the probability integral, and thus the specific term applied to any class within the range of which the relative local difference falls, may or may not apply in such cases. The terms* denoting the significance of the results in the table of class ranges (Table V.) are therefore intended to be strictly applicable only to relative local differences which are abscissal values of a normal curve, and are applicable to those which are abscissal values of a distinctly asymmetrical curve only as a first approximation. With this reservation those relative local differences which fall beyond +2 and −2 may possibly or even probably be significant, those falling beyond +3 and −3 may probably be significant, while those falling beyond +4 and −4 may be regarded as distinctly significant.

(6) *Relative Local Differences geographically considered. Individual differences of each class.* (*Problem b.*)

I. *Explanatory and Introductory.*

In studying the individual relative local differences of each class (that is the individual relative differences, whether the divisions, counties, districts or other

* Tocher: *Biometrika*, Vol. v. p. 318.

smaller areas are considered) the following plan will be followed with respect to Scotland geographically. The distribution of each class with respect to the eight great divisions of Scotland, as understood by the Registrar-General and used in the census and other official reports, will first be considered. Then the county distributions will be noted and finally the distributions with respect to the smallest unit—the district—will be dealt with. Thus the reader (1) will get an appreciation of the nature of the distribution in general terms, *i.e.* the significant inter-divisional differences will be determined and pointed out; (2) will learn how far counties differ from one another, thus enabling the reader to note intra-divisional as well as inter-county differences; and finally (3) will see what localities influence the various county and divisional differences, thus detecting differences occurring within each county—that is, the significant intra-county or purely local differences. It should be noted that the frequencies of the various classes of a character such as hair colour or eye colour are correlated. Thus an excessive frequency of one class would point to a defect in the frequency of one or more of the other classes. Before describing the various differences, it will be useful here to show the total frequencies of each class and their percentages for the whole of Scotland. These are as follow (Table VI.):

TABLE VI.

Colour Distribution of Scottish Children.

	Hair					Eyes				
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	Totals
Boys A	64312	14162	111569	64511	3212	37788	78140	84334	57504	257766
„ B	24·950	5·494	43·283	25·027	1·246	14·660	30·314	32·717	22·309	per cent.
Girls A	67036	12435	99873	62073	2972	36347	74068	78357	55617	244389
„ B	27·430	5·088	40·866	25·399	1·216	14·873	30·307	32·062	22·758	per cent.

Boys A and Girls A=total frequencies of each class for whole of Scotland for boys and girls respectively.

Boys B and Girls B=percentages of each class for whole of Scotland for boys and girls respectively.

The following tables (Tables VII., VIII. and IX.) give the values of the relative local differences for hair colour and eye colour of both boys and girls. These differences, classed as described in Section 5, are shown in the maps, named in the course of the descriptions of the differences in each colour class in this section (Maps III. to XL.), and are the basis of the following remarks:

TABLE VII.

Relative Local Differences. Divisions.

$$\text{Values of } (y_s'' - y_s') \Big/ \sqrt{mpq\left\{1 - \left(\frac{n-1}{N-1}\right)\right\}}.$$

BOYS.

Division	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
I.	2·24	1·96	−6·31	2·91	4·08	6·58	−4·68	·03	− ·46
II.	4·36	− ·56	−9·98	5·66	6·60	12·92	·05	−5·67	−4·64
III.	2·13	6·08	−2·57	−1·69	−2·73	3·69	−1·56	2·15	−3·83
IV.	1·25	−2·99	1·64	−1·83	1·08	4·33	−5·82	− ·50	3·31
V.	− ·57	−2·95	−4·67	6·67	3·09	− 1·27	5·48	−1·74	−3·01
VI.	−8·48	−1·70	7·58	·95	− ·96	−14·38	1·96	4·78	4·66
VII.	3·63	1·60	3·88	−7·87	−4·03	1·22	1·55	−2·73	·33
VIII.	3·13	− ·38	−1·79	− ·19	−2·68	2·48	2·23	−2·20	−2·09

GIRLS.

Division	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
I.	7·20	− ·70	− 4·61	−2·49	2·70	7·19	−2·77	−3·22	·52
II.	4·08	−1·15	−10·13	5·33	9·98	14·25	−1·08	−7·10	−3·01
III.	8·12	5·16	− 4·92	−5·06	−1·28	4·48	−2·10	2·36	−4·13
IV.	4·02	−1·01	− 1·85	−1·61	·32	1·36	−6·50	·75	5·14
V.	− ·24	−2·80	− 2·09	3·33	2·78	− 1·35	6·81	−2·80	−3·20
VI.	−19·99	−1·46	12·60	7·69	−2·73	−11·32	·14	5·03	3·85
VII.	5·68	1·27	1·43	−7·03	−4·15	− ·85	2·41	− ·33	−1·55
VIII.	7·62	− ·50	− 4·68	−2·55	1·10	1·27	4·38	−3·54	−1·94

Explanatory Note on the "Divisions." (See Map I.)

I. = Northern Division (Sutherland group).
II. = North-Western Division (Inverness group).
III. = North-Eastern „ (Aberdeen group).
IV. = East-Midland „ (Perth group).
V. = West-Midland „ (Argyll group).
VI. = South-Western „ (Ayr group).
VII. = South-Eastern „ (Lothian group).
VIII. = Southern „ (Dumfries group).

TABLE VIII.

Relative Local Differences. Counties.

BOYS.

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Aberdeen Co. ...	·33	3·55	– ·27	–2·27	1·52	6·56	–1·27	2·38	–6·86
Aberdeen City ...	– 1·04	3·55	·07	·40	–5·12	– 5·86	1·47	1·71	1·45
Argyll ...	– ·81	– ·81	–7·59	9·40	2·02	– ·47	5·27	–1·08	–4·21
Ayr ...	5·89	– ·77	–3·81	–1·02	– ·38	6·91	3·26	–5·60	–3·15
Banff ...	1·56	3·84	–1·20	–2·03	– ·69	1·10	–4·02	1·48	1·84
Berwick ...	5·72	–1·01	–4·38	– ·39	·85	1·64	3·06	–2·60	–1·85
Bute ...	– 4·56	·59	2·57	·64	2·57	– 4·33	2·56	1·03	– ·31
Caithness ...	·18	1·12	–3·25	1·52	5·54	– 2·90	–2·21	1·98	2·68
Dumbarton ...	3·07	–2·38	–2·50	·68	1·41	– 1·27	4·29	–3·16	– ·09
Dumfries ...	2·93	–2·83	1·59	–2·40	–3·34	– 3·15	3·36	2·69	–4·06
Edinburgh Co. ...	3·10	·12	1·14	–3·79	–2·63	6·28	– ·84	–2·54	–1·55
Edinburgh City ...	3·19	– ·45	– ·62	–1·66	–2·29	1·30	–1·10	–4·84	5·57
Leith ...	– 2·45	1·46	3·32	–1·18	–3·64	– 8·94	3·84	2·36	·70
Elgin & Nairn ...	6·15	·61	–3·44	–2·47	– ·21	8·82	–3·27	–2·02	–1·61
Fife K. & C. ...	1·26	–2·61	2·40	–2·32	–1·18	– 1·43	–1·58	3·19	– ·64
Forfar ...	·54	·06	·58	– ·66	–2·23	8·12	–3·52	–4·74	2·33
Dundee ...	– 3·77	– ·33	4·00	– ·99	1·37	– ·31	–5·92	2·30	4·21
Haddington ...	– ·48	1·14	1·52	–2·15	1·13	5·20	–1·26	–1·09	–1·80
Inverness ...	2·17	– ·83	–7·00	5·23	4·08	8·82	– ·55	–4·79	–1·48
Kincardine ...	– ·11	– ·16	–3·05	3·98	–1·16	– 1·20	3·47	–1·25	–1·41
Kirkcudbright ...	– 2·02	·70	–2·04	4·32	–1·33	1·93	1·30	–2·86	·15
Lanark ...	1·62	– ·08	·25	–5·34	– ·71	– 9·04	1·34	6·76	–1·42
Glasgow ...	–12·00	–1·16	7·36	4·57	–1·52	–18·55	1·04	4·95	9·03
Govan ...	– 7·80	– ·80	7·64	– ·54	·05	– ·09	– ·27	–2·31	2·98
Linlithgow ...	1·37	2·14	2·78	–5·50	– ·64	– ·84	3·01	·45	–3·12
Orkney ...	3·31	– ·91	–2·26	– ·34	·38	3·71	·31	1·62	–5·33
Perth ...	4·29	–2·38	–4·52	·98	4·53	3·30	– ·34	–3·08	1·04
Renfrew ...	– 3·78	– ·43	3·56	– ·47	1·54	·92	–2·61	1·61	·29
Ross & Cromarty	3·96	·06	–6·99	2·67	5·19	9·29	·64	–3·13	–5·07
Roxburgh ...	4·33	1·25	–1·99	–2·59	– ·49	4·54	·74	–5·29	1·28
Selkirk & P. ...	– ·82	·64	5·95	–6·19	– ·50	1·24	–2·88	2·96	–1·20
Shetland ...	1·84	1·88	–2·87	·21	·95	11·74	–5·06	–3·81	– ·09
Stirling ...	– ·90	–2·13	– ·28	2·08	1·02	1·05	– ·08	·28	–1·12
Sutherland ...	– ·94	2·20	–4·44	4·84	·10	3·24	–3·05	– ·93	1·66
Wigtown ...	·45	1·39	–2·30	1·22	·92	3·74	–2·34	– ·32	– ·24

TABLE IX.

Relative Local Differences. Counties.

GIRLS.

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Aberdeen Co. ...	5·19	1·49	−2·34	− 4·11	2·72	4·36	·17	·52	−4·46
Aberdeen City ...	− ·33	2·37	− ·11	·53	−5·05	− 2·78	−1·21	3·65	− ·38
Argyll ...	− ·76	− ·13	−5·44	5·91	4·26	·56	4·20	−1·17	−3·78
Ayr ...	5·61	− ·67	− ·75	− 4·14	−1·67	7·66	1·24	−2·82	−4·71
Banff ...	4·75	5·58	−2·05	− 4·92	−1·79	1·14	−3·00	1·30	·87
Berwick ...	5·67	− ·07	−3·26	− 1·86	− ·97	1·29	2·75	−1·92	−1·96
Bute ...	− 1·16	·52	−1·03	2·03	·19	− 2·91	2·50	1·42	−1·85
Caithness ...	1·94	−1·18	−1·94	− ·08	3·47	− 1·27	·04	− ·89	2·03
Dumbarton ...	1·88	−2·54	−2·67	2·09	1·16	− 2·42	6·93	−3·80	−1·31
Dumfries ...	6·59	−1·11	−2·00	− 3·92	− ·10	− 2·47	3·14	1·77	−3·30
Edinburgh Co. ...	5·88	2·73	1·73	− 8·52	−3·38	3·84	− ·40	·00	− 2·83
Edinburgh City ...	− 1·84	− ·51	·56	1·03	2·00	− ·34	−1·02	−2·83	4·55
Leith ...	·18	− ·43	1·76	− ·91	−4·18	− 8·32	4·32	4·09	−2·22
Elgin & Nairn ...	5·39	·43	−3·66	− 1·87	1·03	6·95	−4·60	·54	−1·46
Fife K. & C. ...	7·57	−2·43	−2·21	− 2·84	−4·79	− 1·94	−2·36	2·49	1·46
Forfar ...	·72	1·14	·34	− 1·96	1·05	4·96	−3·21	−4·91	4·78
Dundee ...	− 5·95	− ·12	3·18	2·08	1·97	− 2·16	−6·32	4·49	3·77
Haddington ...	3·59	·54	−2·47	− ·83	−1·31	3·34	1·25	−2·48	−1·44
Inverness ...	·92	−1·22	−7·30	5·74	8·68	10·71	− ·01	−8·04	− ·13
Kincardine ...	4·38	1·48	−4·55	− ·33	·94	1·91	4·06	−2·77	−2·99
Kirkcudbright ...	1·41	− ·72	−2·14	1·21	·51	− ·90	4·65	−2·55	−1·49
Lanark ...	2·44	1·07	1·24	− 3·14	−5·18	− 5·24	1·58	2·73	− ·32
Glasgow ...	−24·17	−1·93	9·85	14·28	1·40	−14·61	−2·16	6·62	7·40
Govan ...	−12·50	·09	9·53	2·22	− ·84	− 2·07	1·39	−2·35	2·86
Linlithgow ...	4·95	·62	− ·97	− 3·63	−2·64	·49	1·68	− ·58	−1·61
Orkney ...	4·87	− ·27	−2·26	− 2·29	− ·06	4·01	·16	·69	−4·35
Perth ...	3·72	·20	−4·47	·15	3·95	2·93	− ·58	−1·82	·17
Renfrew ...	− 8·37	−1·33	4·51	3·61	2·16	− 2·90	−1·46	2·69	1·08
Ross & Cromarty	4·83	− ·38	−6·89	1·69	5·28	9·24	−1·51	−1·87	−4·11
Roxburgh ...	4·45	1·54	−2·40	− 2·81	·75	2·43	·70	−4·07	1·71
Selkirk & P. ...	− ·61	·71	4·85	− 4·96	−1·00	·34	−1·62	2·90	−1·75
Shetland ...	4·57	·89	−3·24	− 1·77	1·18	9·73	−4·56	−3·32	·43
Stirling ...	− ·79	−2·25	3·33	− 1·81	− ·01	·55	·65	− ·86	− ·22
Sutherland ...	3·58	− ·44	−2·03	− 1·20	·18	4·26	−2·25	−3·74	3·01
Wigtown ...	1·42	− ·34	−2·98	1·74	1·38	5·26	− ·46	−3·87	·34

II. *Differences in Hair Colour.*

Hair colour of both sexes will first be considered. (α) Fair Hair. (Maps III., IV., XXI., XXII. and XXXIX.) The North-Western, South-Eastern and Southern divisions are significantly fair haired, or, using the term for significant excess of a class, these divisions are megalometropic both for boys and girls. Naming the divisions in a way more readily understood geographically, the Inverness group of counties, the Border counties and the Lothians have the greatest excess of fair hair (♂ and ♀) compared with the general population. The distributions for

boys and girls, however, appear to be different. The results for girls show that the whole of Scotland, excepting the West-Midland and South-Western divisions, are megalometropic or conversely—the Argyll and Lanark groups are micrometropic, the proportion of fair hair in these divisions or groups being significantly less than that of the general population. Looking now at the inter-county and intra-county (district) differences it is seen that any megalometropic character in the Northern division is due to Orkney and Shetland and only very slightly to the east coast of Caithness. The following counties north of the Forth are significantly fair haired: viz. Stirling, Perth, Inverness, Ross, Cromarty, Nairn, Elgin and Banff. These are distinctly Highland counties or counties on the Highland line. Examining the districts it is seen that the region of the Cromarty Firth, the region immediately south of the Moray Firth, South Perthshire, South Forfar, except Dundee, the Isle of Lewis, Dunfermline district and the Trossachs, are the specific localities north of the Forth which are significantly fair. Skye and the adjacent mainland are also moderately fair. South of the Forth, Dumbarton (north of Glasgow), Ayr (south of Glasgow), Midlothian and the Border counties are megalometropic. Lanark, excluding Glasgow, is probably megalometropic. The specific localities significantly fair or megalometropic, south of the Forth, are North Ayr, North Lanark, Midlothian, Berwick and a portion of Roxburgh. On the whole the county distributions for boys and girls correspond. Haddington, Fife and Linlithgow are significantly fair haired counties in the girl population. In view of the fact that significant excess appears in so many large areas, one must enquire where the micrometropic population is. The most outstanding cases are the cities of Glasgow, Dundee, Leith and Greenock. The relative difference in Glasgow is so great ($RLD = -12{\cdot}00$ and $-24{\cdot}17$ for boys and girls respectively) as to point to exceptional circumstances with respect to this great city. The colour distribution is entirely different from any other part of Scotland. A separate section will therefore be devoted to Glasgow and to problems bearing on the relationship between density of the population generally and colour. Aberdeen city is like the general population, while Edinburgh is significantly fair haired, slightly more so than the surrounding population. Hawick, Airdrie, Dunfermline, Forfar, Hamilton, Dumbarton and Perth are megalometropic towns; Stirling, Kirkcaldy, Rutherglen, Montrose and Peterhead are micrometropic; while Paisley, Kilmarnock, Ayr, Arbroath, Inverness, Falkirk, Dumfries, Dysart and Galashiels are mesometropic, *i.e.* these towns are like the general population.

Generally speaking, excess of fair hair is found both in the Highlands and the Lowlands in Scotland, but it cannot be said that this class is characteristic of either—the distribution is far from uniform. In the Highlands, fair hair is more characteristic of the boundaries than of the heart of the Highland country. *The Moray and Cromarty Firths, East Perthshire, the Trossachs, Dumbarton, Lewis, and East Caithness encircle and are mostly part of the Highlands, and these districts are significantly fair populations. The Borders, North Ayr, and parts of Lanark and Midlothian, as against Galloway, Selkirk, Peebles, Glasgow, and the region*

surrounding Glasgow, are fair Lowland districts. Orkney and Shetland are both significantly fair, the only distinguishing feature in hair colour among the population of these islands.

(β) Red Hair. (Maps V., VI., XXIII., XXIV. and LX.) Significant excess of red hair is confined (♂ and ♀) to the North-East division; there is a possible significant excess for boys also in the Northern and South-Eastern divisions. The counties of Aberdeen and Banff stand out clearly as having the greatest excess in the North-Eastern division; Midlothian, Roxburgh, Orkney and Shetland (for boys); Linlithgow and Sutherland (for girls) are also megalometropic. Proportions slightly above the average occur in Haddington, the Borders, Galloway, Arran and Caithness (♂), and in Haddington, Lanark, Peebles, Selkirk, Arran, Forfar and

TABLE X.

County Specification. Fair Hair. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Ayr Berwick Elgin & Nairn Perth Ross & Cromarty Roxburgh Banff ♀ Aberdeen ♀ Dumfries ♀ Edinburgh Co. ♀ Fife ♀ Haddington ♀ Kincardine ♀ Linlithgow ♀ Orkney ♀ Shetland ♀ Sutherland ♀	Dumbarton ♂ Dumfries ♂ Edinburgh Co. ♂ *Edinburgh City* ♂ Orkney ♂	*Aberdeen City* Argyll Caithness *Leith* Forfar Inverness Kirkcudbright Lanark Selkirk & Peebles Stirling Wigtown Aberdeen ♂ Banff ♂ Fife K. & C. ♂ Haddington ♂ Kincardine ♂ Linlithgow ♂ Shetland ♂ Sutherland ♂ Bute ♀ Dumbarton ♀ *Edinburgh City* ♀		*Dundee* *Glasgow* *Govan* Renfrew Bute ♂

Kincardine (♀); but in none of these cases can the differences be said to be at all significant. Only on the border of the North Highlands is there even the slightest excess of red hair. *It is quite clear that the population north of the Grampians and east of the Caledonian Canal is the only one in Scotland where red hair persists quite above the average. Special notice of this peculiarity is taken in a later section.*

TABLE XI.

County Specification. Red Hair. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Banff Aberdeen Co. ♂ *AberdeenCity* ♂	Edinburgh Co. ♀	Argyll Ayr Berwick Bute Caithness *Edinburgh City* *Leith* Elgin & Nairn Forfar *Dundee* Haddington Inverness Kincardine Kirkcudbright Lanark *Glasgow* *Govan* Linlithgow Orkney Perth Renfrew Ross & Cromarty Roxburgh Selkirk Shetland Stirling Sutherland Wigtown Dumbarton ♂ Edinburgh Co. ♂ Aberdeen Co. ♀ *Aberdeen* ♀ Dumfries ♀ Fife K. & C. ♀	Dumfries ♂ Fife K. & C. ♂ Dumbarton ♀	

(γ) Medium Hair. (Maps VII., VIII., XXV. and XXVI.) Excess of medium or brown of various shades is peculiar to the Scottish Midlands, there being corresponding defects in the north, the Borders and Galloway. The East-Midland, South-Western and South-Eastern populous divisions show for boys significant excess. In only one division—the South-Western—is there significant excess among the girls. Among the counties, Renfrew, Selkirk and Peebles are megalometropic for both sexes; Stirling and Midlothian for girls only; Linlithgow, Fife, Dumfries and Haddington for boys only. Glasgow, Dundee and Leith are megalometropic towns. *As will be seen later, brown or medium hair is characteristic of densely populated parts.*

TABLE XII.

County Specification. Medium Hair. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Distinctly	Probably
Glasgow *Govan* Renfrew Selkirk & Peebles *Dundee* ♂	Bute ♂ *Leith* ♂ Linlithgow ♂ *Dundee* ♀ Stirling ♀	Aberdeen Co. *Aberdeen City* Banff Dumfries Edinburgh Co. *Edinburgh City* Fife K. & C. Forfar Haddington Kirkcudbright Lanark Orkney Roxburgh Dumbarton ♂ Stirling ♂ Wigtown ♂ Ayr ♀ Bute ♀ Caithness ♀ *Leith* ♀ Linlithgow ♀ Sutherland ♀	Shetland Caithness ♂ Elgin & Nairn ♂ Kincardine ♂ Berwick ♀ Dumbarton ♀ Wigtown ♀	Argyll Inverness Perth Ross & Cromarty Ayr ♂ Berwick ♂ Sutherland ♂ Elgin & Nairn ♀ Kincardine ♀

(δ) Dark Hair. (Maps IX., X., XXVII. and XXVIII.) The distribution of dark hair is very striking. Significant excess is found in the entire west of Scotland, and compared with the general population there is a corresponding significant defect of this class in the east. The Northern, North-Western and West-Midland divisions (♂) and the North-Western, West-Midland and South-Western divisions (♀) are distinctly megalometropic. The South-Western division for boys shows slight excess. Examining the counties, it is seen that Sutherland, Ross and Cromarty, Inverness, Argyll and Kirkcudbright, all in the west, are for boys megalometropic. Kincardine (♂) is the sole eastern megalometropic county. Significant excess among the girl population occurs only in the counties of Ross and Cromarty, Inverness, Argyll, Renfrew and Wigtown. There is only a slight excess in Kirkcudbright. Examining the districts it is seen that Mull, Jura and the portion of the mainland opposite is the most significantly dark population of Scotland. Then follow the remaining portion of Argyll, the western portions of Inverness, Ross and Cromarty (*excluding Skye*) and Sutherland. Although Ayrshire (♂) is not megalometropic, the southern portion below Ayr itself is, the district analysis showing significant excess in the Doon region and also in the southern portion of Galloway (Wigtown and South Kirkcudbright). The district

analysis shows the same restricted nature of the distribution in the girl population. Wigtown is the only portion of Galloway with excess. The extreme north of Ayrshire (and not the south as among ♂), and an isolated portion on the Moray Firth (Dornoch and Tain) are also dark-haired districts. Dundee, Edinburgh and Aberdeen show among the girls a slight excess of dark hair, Dundee being the most marked. Summing up the results for this class, *it is found that the Highlands, Galloway and the city of Glasgow are the populations which show significant excess of dark hair.* There is therefore clearly a sharp distinction geographically, and, as will be shown later, racially in the distribution of this class of hair colour. The east, excepting the slight excesses in Edinburgh and Aberdeen cities (♀), a small portion of the coast-line north of Montrose and Donside (♂) is characterised by a significant defect in the expected proportion of dark hair compared with what would occur on an even distribution of that class throughout the whole country.

TABLE XIII.

County Specification. Dark Hair. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Argyll Inverness *Glasgow* Kincardine ♂ Kirkcudbright ♂ Sutherland ♂ Renfrew ♀	Ross & Cromarty ♂	*Aberdeen City* Berwick Bute Caithness Dumbarton *Edinburgh City* *Leith* Elgin & Nairn Forfar *Dundee* Haddington *Govan* Orkney Perth Shetland Stirling Wigtown Aberdeen Co. ♂ Ayr ♂ Banff ♂ Dumfries ♂ Fife K. & C. ♂ Renfrew ♂ Kincardine ♀ Kirkcudbright ♀ Ross & Cromarty ♀ Sutherland ♀	Roxburgh Fife ♀ Lanark ♀	Edinburgh Co. Linlithgow Selkirk & Peebles Lanark ♂ Aberdeen Co. ♀ Ayr ♀ Banff ♀ Dumfries ♀

(ε) Jet Black Hair. (Maps XI., XII., XXIX. and XXX.) In a general way, the distribution of jet black hair resembles that of dark hair. While this however is the case, the jet black class seems to be more scattered than the dark-haired class. Taking the divisions first, the Northern, North-Western and West-Midland divisions are clearly megalometropic both for boys and girls. The North-Eastern, South-Eastern and Southern (♂), the South-Eastern and South-Western (♀), are micrometropic; the remaining divisions are fair samples of the general population—they are mesometropic. Surveying the counties, it is seen that the excess in the Northern division is due to Caithness; the excess of the North-Western division is equally divided among the respective counties, while the excess of the West-Midland division is due to Argyll and Bute and slightly to Dumbarton. In the South-Western division, although itself meso- (♀) or micrometropic (♂), the county of Renfrew stands alone in showing significant excess of this class. The East-Midland and North-Eastern divisions are not at all uniform in their distribution of jet black hair. Thus (♂ and ♀) Perth resembles the contiguous county of Argyll in showing excess; only the eastern portion (♂) is micrometropic. Among girls, Fife is the only eastern county in this division which is micrometropic. The other eastern counties and Dundee show a slight excess over the general population. Aberdeenshire (but not Aberdeen city) stands out as megalometropic, although the North-Eastern division itself is either meso- (♀) or micrometropic (♂). Taking now a more detailed view of the distribution locally, one notes that, starting from John o' Groat's, excess of jet black hair runs along the coast to Inverness, where it leaves the coast and permeates the upper regions of the Findhorn, Spey and Donside. A slight excess is found along the Buchan coast. It is absent again until the Forfar and Fife coasts are reached, when again slight excess is noticed. It is in defect south of the Forth on the coast-line. Running inwards from Fife and Forfar the excess increases and reaches a maximum in North Perthshire, where it unites with the excess in the Spey valley and the slight excess of Donside. Southwards from Perthshire it reaches Stirling, Dumbarton, and a portion of Renfrew. Northwards it runs through Inverness, part of Ross, and on to Skye and Lewis. It avoids the main portion of Argyll where there is great excess of dark hair, but affects the portion contiguous to Skye and Inverness, *i.e.* the mainland to Ardnamurchan Point, and the Isles of Mull, Tyree, Coll and Rum. An isolated spot occurs in Wigtown (♀), and in North Ayr and the contiguous portion of Lanark (♂). *A general view of this class, small numerically, shows that jet black hair, like dark hair, is characteristic of Highland counties, but that the distribution is not so restricted as in the case of dark. There is a greater scatter in the distribution for boys than in the corresponding distribution for the girl population.*

TABLE XIV.

County Specification. Jet Black Hair. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Inverness Perth Ross & Cromarty Caithness ♂ Argyll ♀	Bute ♂ *Aberdeen City* ♀ Caithness ♀	Ayr Banff Berwick Dumbarton *Edinburgh City* Elgin & Nairn Forfar *Dundee* Haddington Kincardine Kirkcudbright *Glasgow* *Govan* Orkney Renfrew Roxburgh Selkirk & Peebles Shetland Stirling Sutherland Wigtown Aberdeen Co. ♂ Argyll ♂ Fife K. & C. ♂ Lanark ♂ Linlithgow ♂ Bute ♀ Dumfries ♀	Edinburgh Co. Dumfries ♂ Linlithgow ♀	*Aberdeen City* *Leith* Fife K. & C. ♀ Lanark ♀

III. *Differences in Eye Colour.* (α) Blue Eyes. (Maps XIII., XIV., XXXI. and XXXII.) The general percentage for blue eyes among boys is 14·66 and among girls is 14·87. The greatest excess is found in Shetland and the smallest percentage in Glasgow. Noting first the general distribution it is seen that the north is distinctly the blue-eyed region. The Northern, North-Western, North-Eastern (♂ and ♀) and East-Midland (♂) are significantly blue-eyed. The South-Eastern (♂) and Southern (♂ and ♀) show slight excess. The South-Western (♂ and ♀) is distinctly micrometropic—there is quite a deficiency of blue eyes in this division compared with the general population. The West-Midland division is only slightly micrometropic. Examining the county distributions, one finds that Orkney, Shetland and Sutherland (but not Caithness) are significantly blue-eyed; all the counties in the North-Western division (♂ and ♀) are also megalometropic; in the East-Midland division, Perth and Forfar (but not Kincardine, the coast, Dundee and Fife) are also quite significant in their

excess of blue eyes. Midlothian and Haddington (South-Eastern division) show significant excess; Berwick (♂) only a slight excess. Wigtown and Roxburgh (of the Southern division) and only Ayr (South-Western division) are megalometropic counties with respect to blue eyes. On the county basis of analysis, the tract of country stretching from Fife through the Midlands to Dumbarton and southwards through Stirling, Linlithgow, Lanark, Renfrew, Peebles, Selkirk, Kirkcudbright and Dumfries, is characterised by a deficiency (in many localities highly significant) of the blue-eyed class of children. Argyll alone of the Highland counties shows no bias in favour of blue eyes; it is like the general population. Examining the distribution from the results of the district analysis it is seen that there is no significant excess on the east coast except in the Elgin district. Inwards from Elgin, north to Sutherland, west to Lewis, south to the border of Argyll and North Perthshire, and east through the Spey region to West Aberdeenshire, blue eyes is quite in excess of the general population both for boys and girls. The excess is small in Mid Perthshire, increases in the south of the county and diminishes rapidly in passing into Stirlingshire and the populous region between the Forth and the Clyde. Turning eastwards, the excess becomes significant in North-East Lanarkshire and the neighbourhood of Linlithgow. In the Lothians, the excess found there by the county analysis is shown by the district analysis to be fairly evenly distributed. No great city shows excess of the blue-eyed population. On the contrary, there is a significant defect in each,

TABLE XV.

County Specification. Blue Eyes. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Aberdeen Co. Ayr Edinburgh Co. Elgin & Nairn Forfar Inverness Orkney Ross & Cromarty Shetland Wigtown Haddington ♂ Roxburgh ♂ Sutherland ♀	Perth Sutherland ♂ Haddington ♀	Argyll Banff Berwick Dumbarton *Edinburgh City* Fife K. & C. *Dundee* Kincardine Kirkcudbright *Govan* Linlithgow Selkirk & Peebles Stirling Renfrew ♂ Caithness ♀ Dumfries ♀ Roxburgh ♀	Caithness ♂ Dumfries ♂ *Aberdeen City* ♀ Bute ♀ Renfrew ♀	*Leith* Lanark *Glasgow* *Aberdeen City* ♂ Bute ♂

excepting Edinburgh (♂ and ♀), and Dundee (♂), which approximate the general population in distribution.

Looking at the distribution of blue eyes in the division and county maps, it seems a very wide one. That is, geographically considered it is wide, but it must of course be kept in mind that the areas shown are very sparsely populated. The populous area between Edinburgh and Glasgow and the populous centres are mainly defective in blue eyes. Thus the question of density again arises. It will be seen later that just as fair hair is negatively correlated to density so also are blue eyes.

(β) Light Eyes. (Maps XV., XVI., XXXIII. and XXXIV.) The proportion of light-eyed children in the general population is 30·314 per cent. for boys and 30·307 per cent. for girls. The West-Midland division (that is, the Argyll group) stands out prominently as the only division where significant excess of light eyes occurs both among boys and girls. The Southern or Galloway division is also significant for girls, while the South-Eastern or Midlothian division (♂ and ♀), Galloway (♂), the South-Western (♂) have a moderate but not a significant

TABLE XVI.

County Specification. Light Eyes. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Argyll Dumbarton *Leith* Kincardine ♀ Kirkcudbright ♀	Berwick Dumfries Ayr ♂ Bute ♂ Kincardine ♂ Linlithgow ♂	Aberdeen Co. *Aberdeen City* Caithness Edinburgh Co. *Edinburgh City* Fife K. & C. Haddington Inverness Lanark *Glasgow* *Govan* Orkney Perth Ross & Cromarty Roxburgh Stirling Wigtown Kirkcudbright ♂ Ayr ♀ Bute ♀ Linlithgow ♀ Renfrew ♀ Selkirk & Peebles ♀ Sutherland ♀	Elgin & Nairn ♂ Renfrew ♂ Selkirk & Peebles ♂ Sutherland ♂ Banff ♀ Forfar ♀	*Dundee* Shetland Banff ♂ Forfar ♂ Elgin & Nairn ♀

excess of this class. It is seen from the county analysis that Argyll and Arran account for the excess in the West Midland division (♂ and ♀), Dumbarton also contributing in the case of the girl population. Taking the more local view revealed by the district analysis, it is found that the excess in Argyll thins off through Inverness to Ross, where it disappears. It extends eastwards and northwards through Mid Perthshire and over to Deeside and the Kincardine coast. All these are thinly populated districts. In the populous districts between Edinburgh and Glasgow excess appears sporadically here and there. It runs from Glasgow and Greenock through Renfrew, North Ayr to Kirkcudbright and South Dumfries, a slight break occurring in the district inland from the town of Ayr. Finally, south of the Lothians, a tract from Peebles to Berwick shows moderate excess. Passing from the purely local distribution to the distribution in a general sense, *it is quite clear that the light-eyed class is more characteristic of the south than of the north. The excess is more marked in the girl population.* Renfrew, Selkirk and Peebles are the exceptions. These counties are slightly micrometropic, or, compared with the general population, the proportion of the light-eyed class is scarcely so great, although not significantly less.

(γ) Medium Eyes. (Maps XVII., XVIII. XXXV. and XXXVI.) Turning now to the mixed class of eye defined as medium, it is found that there is 32·72 per cent. of this class for boys and 32·06 per cent. for girls in the general population. The only division in Scotland where this class is in significant excess is the populous South-Western division or Lanark group of counties. This result is found for both boys and girls. The North-Eastern division or Aberdeen group shows a moderate excess (♂ and ♀), but the excess is not greater than could quite possibly occur in making a random selection of the same number from the general population. Examining the distribution with respect to counties, it is seen that Lanark (excluding Glasgow), Dumfries, Selkirk and Peebles—just those counties deficient in all the other classes (excepting Dumfries which has also excess of light eyes)—are the megalometropic counties of this class. These counties are all contiguous and the result is common to both boys and girls. The counties of Fife and Aberdeen and the cities of Dundee and Aberdeen have also an excess of medium eyes (♂ and ♀). Caithness (♂) and the Orkney Islands show a moderate excess of the class. Taking the local distribution, it is found that West Renfrew, North Lanark stretching into Stirling, Selkirk and the town of Dumfries, are the areas where the greatest excess is shown in these counties. West Fife in Fifeshire, the southern portion of the Buchan coast in Aberdeenshire, account for the moderate excess found in these counties. The coast from John o' Groat's to Banff, with one or two local exceptions, shows an excess of the medium class. Taking a general view of the distribution of medium eyes, *it is seen that excess of the class is restricted to an area commencing with Fife and extending right to Dumfries through Lanark. The other regions of excess are more or less detached from this region.*

TABLE XVII.

County Specification. Medium Eyes. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Glasgow Lanark ♂ *Aberdeen City* ♀ *Leith* ♀ *Dundee* ♀	Selkirk & Peebles Dumfries ♂ Fife K. & C. ♂ Lanark ♀ Renfrew ♀	Aberdeen Co. Argyll Banff Bute Caithness Elgin & Nairn Haddington *Govan* Linlithgow Orkney Stirling *Aberdeen City* ♂ *Leith* ♂ *Dundee* ♂ Kincardine ♂ Renfrew ♂ Sutherland ♂ Wigtown ♂ Berwick ♀ Dumfries ♀ Edinburgh Co. ♀ Fife ♀ Perth ♀ Ross & Cromarty ♀	Kirkcudbright Berwick ♂ Dumbarton ♂ Edinburgh Co. ♂ Perth ♂ Ross & Cromarty ♂ Ayr ♀ *Edinburgh* ♀ Kincardine ♀ Shetland ♀	Forfar Inverness Roxburgh Ayr ♂ *Edinburgh City* ♂ Shetland ♂ Dumbarton ♀ Sutherland ♀ Wigtown ♀

(δ) Dark Eyes. (Maps XIX., XX., XXXVII. and XXXVIII.) The percentage of dark eyes in the general population of boys is 22·31; in the general girl population it is 22·76. The distribution of dark eyes from the point of view of the 'division' analysis shows excesses in the South-Western or Lanark division and the East-Midland or Perth-Forfar division. The buffer county of Stirling, belonging to the West-Midland division, resembles the general population. The North-Western, West-Midland and North-Eastern divisions are all distinctly micrometropic (both ♂ and ♀) for this class. The other divisions are slightly micrometropic or are mesometropic. Examining the results of the county analysis it is noted that Dundee city and Forfar county are responsible for the significant excess in the East-Midland division, while Glasgow alone is responsible for the excess in the South-Western division. Outside these divisions there is a probably significant excess in the counties of Caithness and Sutherland. A slight excess occurs in Banffshire as also in the county of Roxburgh. Taking a local view it is found that an excess occurs in the south and east of the county of Lanark, in South Ayrshire, East Fife and the neighbourhood of Perth, besides the cases just mentioned. *The most striking feature in the distribution of dark eyes is the*

fact that excess is in the main confined to the great cities. These cities are deficient in blue eyes. There does not seem to be any great bias in favour of or against light and medium eyes, but there does seem to be a bias in favour of dark as against blue in the chief cities of Scotland.

TABLE XVIII.

County Specification. Dark Eyes. Both Sexes.

The sign ♂ indicates boys only; and ♀, girls only.

Megalometropic		Mesometropic	Micrometropic	
Distinctly	Probably		Probably	Distinctly
Edinburgh City *Dundee* *Glasgow* Forfar ♀	*Govan* Caithness ♂ Sutherland ♀	*Aberdeen City* Banff Berwick Bute Dumbarton *Leith* Elgin & Nairn Fife K. & C. Haddington Inverness Kirkcudbright Lanark Perth Renfrew Roxburgh Selkirk & Peebles Shetland Stirling Wigtown Edinburgh Co. ♂ Forfar ♂ Kincardine ♂ Sutherland ♂ Caithness ♀ Linlithgow ♀	Ayr ♂ Linlithgow ♂ Dumfries ♀ Edinburgh Co. ♀ Kincardine ♀	Aberdeen Co. Argyll Orkney Ross & Cromarty Dumfries ♂ Ayr ♀

(7) *The General Resemblance of Local Populations to the General Population.*

I. Introductory. II. Hair Colour as a Character, all Classes constituting the Character being considered together. III. Eye Colour as a Character, all Classes constituting the Character being considered together.

I. *Introductory.* (α) Class frequencies constituting a character are here considered as a whole for each locality (division, county or district), that is to say, intralocally and collectively, and compared with the proportional class frequencies of the general population. (β) As an alternative method, leading to the same result, class frequencies collectively of one locality are compared with the class frequencies collectively of the remaining population and the extent of divergency of the local population measured.

In the previous section the difference between each local group and the general population, *i.e.* the (*RLD*)'s for each colour class, were detected and discussed. In doing so, the significance or non-significance of these differences for each local group (division, county or district) was determined for each colour class or category. It has been noted that for each class of hair colour or of eye colour, many localities exhibit significant differences from the general population. In others the differences may be insignificant, while in a few localities the differences may be considerable although not quite significant. But it is possible that a locality may exhibit a difference or differences almost or just significant for one or more colour classes and yet, when the differences of all the classes constituting the character (either hair colour or eye colour) in any one locality are considered collectively, these differences as a whole may quite conceivably occur even if the locality in question were a fair sample of the general population. A comparison between the entire pigmentation of each local group and the entire pigmentation of the general population is therefore necessary, in order to detect what local groups really diverge and what local groups do not diverge significantly from the general population, for the two characters under consideration, namely, hair colour and eye colour. In other words, the degree of general resemblance of local populations (firstly in hair colour and secondly in eye colour) to the general population is to be determined. Such a determination can be made at least in two ways, and has already been made in the pigmentation of one fairly long series, namely, the Scottish Insane.

(α) One can observe for each locality how closely the observed frequencies of the various classes of hair colour or eye colour as a group correspond to their respective theoretical frequencies—the theoretical frequencies meaning of course, as already noted, those which would be got if, for each locality, the frequencies of the various classes constituting the character were proportionally the same as the frequencies found in the general population The probability that differences in the class frequencies would arise at random in any locality as great as, or greater than, the observed set of differences in class frequencies, can be found by evaluating

$$P=\sqrt{\frac{2}{\pi}}\int_{\chi}^{\infty}e^{-\frac{1}{2}\chi^2}d\chi+\sqrt{\frac{2}{\pi}}e^{-\frac{1}{2}\chi^2}\left(\frac{\chi}{1}+\frac{\chi^3}{1.3}+\frac{\chi^5}{1.3.5}+\ldots+\frac{\chi^{n'-3}}{1.3.5\ldots(n'-3)}\right)$$

if n' be even, and

$$P=e^{-\frac{1}{2}\chi^2}\left(1+\frac{\chi^2}{2}+\frac{\chi^4}{2.4}+\frac{\chi^6}{2.4.6}+\ldots+\frac{\chi^{n'-3}}{2.4.6\ldots(n'-3)}\right)$$

if n' be odd,

where $n'=n+1$ classes in the series constituting the character, m_r = theoretical frequency of any class, m_r' = observed frequency of any class and

$$\chi^2=S\left\{\frac{(m_r-m_r')^2}{m_r}\right\}.$$

This is Pearson's test of goodness of fit* and is applicable, in the manner above stated, to the present data.

(β) One can determine the divergency in hair colour or eye colour of any locality from the remaining population by measuring how far the local group deviates from being a random sample of the general population. This can be done by forming a divergency table and evaluating the mean square contingency coefficient which measures the degree of departure of the local group from complete resemblance to the general population, or the degree of relative divergency of the local group. Such tables† have already been formed for the purpose of determining the relative divergency of the local insane from the general insane population with respect to pigmentation. In a divergency table two groups of the population are dealt with, the local group and the remaining population, but of course the number of classes is not limited. In this investigation the number of classes is small, five for hair colour and four for eye colour. The frequencies for a particular class, S, of the two groups form a column of the table, while the frequencies of all the different classes of either group form a row of the table. If χ'^2 = the total square contingency coefficient and $\chi^2 = S\left\{\frac{(m_r - m_r')^2}{m_r}\right\}$; n = number in any local group and N = total population, then the relation $\chi'^2 = \frac{N}{N-n}\chi^2$ holds between χ'^2 and χ^2; or χ^2 is a fraction of the total square contingency, being, as seen in the working, a partial summation of χ'^2. The mean square contingency coefficient is of course

$$C_1 = \sqrt{\frac{\chi'^2/N}{1+\chi'^2/N}}.$$

Since χ^2 has already been calculated, the above formula need not be used. In terms of χ^2

$$C_1 = Q = \sqrt{\frac{\chi^2}{N-n+\chi^2}},$$

and is readily obtained. Since Q measures the divergence of a local group from the remaining population, it is called the *divergency coefficient*. The probable errors of Q have not been evaluated, except in one or two instances. It is sufficient to note that any value of $Q > \cdot 008$ in the present series is probably significant. The values of Q and $\log P$ have been calculated for all the forms of local groups, namely, divisions, counties and districts, and are given in the following tables (Tables XIX., XX., XXI. and XXII.). These two sets of constants have been classed, the classification being the same as that previously adopted for the pigmentation of adults‡. As may be seen from the maps, Class O with values of $\log P < \overline{3}$ and $Q < \cdot 008$ is the non-significant class, the localities belonging to this class being similar on the whole to the general population.

* *Phil. Mag.* Vol. I. pp. 157—175, July 1900.

† Tocher: *Biometrika*, Vol. v. pp. 333, 334. For theory and probable errors see Pearson, *Biometrika*, Vol. v. pp. 198—203.

‡ Tocher: *Biometrika*, Vol. v. pp. 335—340.

II. *Hair colour.* (α) *Divisions.* Considering first the divisions it is seen on referring to the table (Table XIX.) and maps (Maps XLI. and XLII.) that the East-Midland division resembles the general population in hair colour, both boys

TABLE XIX.

Divergency in Hair Colour and Eye Colour. Divisions.

Division of Scotland	Hair				Eyes			
	Boys		Girls		Boys		Girls	
	Log *P*	*Q*	Log *P*	*Q*	Log *P*	*Q*	Log *P*	*Q*
1	$\overline{1}0{\cdot}3$	·0143	$\overline{1}2{\cdot}3$	·0160	$\overline{1}1{\cdot}7$	·0143	$\overline{1}2{\cdot}8$	·0152
2	$\overline{2}8{\cdot}9$	·0231	$\overline{3}9{\cdot}5$	·0281	$\overline{3}7{\cdot}2$	·0265	$\overline{4}4{\cdot}1$	·0296
3	$\overline{9}{\cdot}8$	·0141	$\overline{1}9{\cdot}5$	·0210	$\overline{5}{\cdot}4$	·0104	$\overline{7}{\cdot}7$	·0123
4	$\overline{2}{\cdot}1$	·0076	$\overline{3}{\cdot}8$	·0083	$\overline{9}{\cdot}8$	·0137	$\overline{9}{\cdot}2$	·0146
5	$\overline{1}2{\cdot}8$	·0157	$\overline{5}{\cdot}9$	·0103	$\overline{6}{\cdot}4$	·0110	$\overline{9}{\cdot}3$	·0139
6	$\overline{1}1{\cdot}3$	·0188	$\overline{4}7{\cdot}0$	·0380	$\overline{2}8{\cdot}8$	·0286	$\overline{1}8{\cdot}5$	·0237
7	$\overline{1}5{\cdot}7$	·0180	$\overline{1}4{\cdot}4$	·0181	$\overline{2}{\cdot}7$	·0058	$\overline{1}{\cdot}1$	·0052
8	$\overline{3}{\cdot}6$	·0080	$\overline{1}2{\cdot}9$	·0158	$\overline{3}{\cdot}4$	·0077	$\overline{5}{\cdot}2$	·0103

and girls, more than in any part of Scotland. The Southern division (♂) and the West-Midland division (♀) approximate more closely to the general population in the distributions of hair colour than the remaining divisions. All the other divisions diverge widely from the general population. The divergency is greatest in the North-Western division for both sexes. This is clearly due to the excesses of dark, jet black and fair hair in this division and the comparative absence of medium. Red hair is only slightly in defect in the division.

(β) Examining the general distributions in the county groups, it is noted that the eastern counties generally can passably be described as samples of the general population. The Northern Isles (♂), Aberdeen (♂), Kincardine (♂), Forfar (♂ and ♀), excluding Dundee, Fife (♂), Haddington (♂), Stirling, right to Dumbarton in the West (♂ and ♀), and also Lanark (♂), excluding Glasgow, show, by their divergency coefficients being small, < ·008, that their populations approximate the general population in hair colour. Kirkcudbright and Wigtown in the extreme south are also like the general population. The rest of Scotland shows great divergency from the general population in its distribution of hair colour. For instance the north-west region, owing to both its darkness and fairness, and the south-east region contiguous to the Border, owing to its fairness and brownness, are widely divergent. Can any reason or reasons be assigned why certain counties or areas are more like or more unlike the general population than others? References to the maps (Maps XLIII. to XLVI.) and to the following table (Table XXIII.) show that at least for the boy population the counties which show

least divergency for hair colour are just those counties densely populated, Lanark, Stirling and the like.

It must be remembered that the four great cities, Glasgow, Edinburgh, Dundee and Aberdeen, are excluded from the county analysis. Three of these, Glasgow, Dundee and Aberdeen, show significant divergency, that of Glasgow being very great. Edinburgh, however, resembles the general population.

Now if an urban population consisted of persons coming from all parts of the country indiscriminately, each group in the densely populated area would be a fair

TABLE XX.

Divergency in Hair Colour and Eye Colour. Counties.

Counties	Hair				Eyes			
	Boys		Girls		Boys		Girls	
	Log *P*	*Q*	Log *P*	*Q*	Log *P*	*Q*	Log *P*	*Q*
Aberdeen Co. ...	$\bar{3}\cdot2$	·0084	$\bar{5}\cdot6$	·0105	$\bar{16}\cdot8$	·0174	$\bar{6}\cdot1$	·0114
Aberdeen City ...	$\bar{7}\cdot3$	·0123	$\bar{6}\cdot7$	·0114	$\bar{7}\cdot5$	·0116	$\bar{3}\cdot1$	·0083
Argyll ...	$\bar{21}\cdot5$	·0201	$\bar{12}\cdot3$	·0159	$\bar{7}\cdot4$	·0115	$\bar{5}\cdot4$	·0100
Ayr ...	$\bar{8}\cdot0$	·0118	$\bar{7}\cdot3$	·0126	$\bar{15}\cdot2$	·0173	$\bar{15}\cdot9$	·0173
Banff ...	$\bar{4}\cdot7$	·0088	$\bar{14}\cdot7$	·0169	$\bar{3}\cdot0$	·0080	$\bar{2}\cdot5$	·0061
Berwick ...	$\bar{7}\cdot2$	·0120	$\bar{6}\cdot1$	·0116	$\bar{3}\cdot1$	·0079	$\bar{3}\cdot9$	·0070
Bute ...	$\bar{5}\cdot4$	·0101	$\bar{1}\cdot5$	·0045	$\bar{6}\cdot0$	·0091	$\bar{3}\cdot2$	·0080
Caithness ...	$\bar{8}\cdot9$	·0124	$\bar{3}\cdot1$	·0086	$\bar{4}\cdot5$	·0085	$\bar{1}\cdot2$	·0046
Dumbarton ...	$\bar{3}\cdot1$	·0084	$\bar{3}\cdot3$	·0085	$\bar{4}\cdot1$	·0090	$\bar{10}\cdot2$	·0142
Dumfries ...	$\bar{6}\cdot7$	·0109	$\bar{9}\cdot5$	·0138	$\bar{7}\cdot4$	·0115	$\bar{5}\cdot8$	·0096
Edinburgh Co. ...	$\bar{5}\cdot7$	·0100	$\bar{20}\cdot6$	·0201	$\bar{8}\cdot1$	·0125	$-\cdot6$	·0088
Edinburgh City ...	$\bar{3}\cdot7$	·0077	$\bar{1}\cdot1$	·0056	$\bar{9}\cdot9$	·0128	$\bar{6}\cdot0$	·0095
Leith City ...	$\bar{5}\cdot4$	·0102	$\bar{4}\cdot8$	·0090	$\bar{17}\cdot3$	·0179	$\bar{18}\cdot4$	·0189
Elgin & Nairn ...	$\bar{8}\cdot7$	·0125	$\bar{6}\cdot2$	·0116	$\bar{18}\cdot0$	·0175	$\bar{12}\cdot4$	·0154
Fife K. & C. ...	$\bar{3}\cdot6$	·0080	$\bar{15}\cdot5$	·0179	$\bar{2}\cdot3$	·0064	$\bar{4}\cdot8$	·0073
Forfar ...	$\bar{1}\cdot4$	·0047	$\bar{1}\cdot4$	·0048	$\bar{17}\cdot1$	·0181	$\bar{13}\cdot7$	·0159
Dundee City ...	$\bar{4}\cdot4$	·0093	$\bar{7}\cdot2$	·0126	$\bar{9}\cdot9$	·0127	$\bar{12}\cdot9$	·0152
Haddington ...	$\bar{1}\cdot1$	·0054	$\bar{3}\cdot6$	·0080	$\bar{6}\cdot7$	·0103	$\bar{3}\cdot0$	·0082
Inverness ...	$\bar{14}\cdot9$	·0163	$\bar{27}\cdot6$	·0233	$\bar{17}\cdot0$	·0180	$\bar{30}\cdot8$	·0241
Kincardine ...	$\bar{3}\cdot0$	·0085	$\bar{6}\cdot9$	·0109	$\bar{3}\cdot9$	·0069	$\bar{6}\cdot9$	·0105
Kirkcudbright ...	$\bar{4}\cdot4$	·0092	$\bar{1}\cdot3$	·0050	$\bar{2}\cdot3$	·0062	$\bar{5}\cdot9$	·0095
Lanark ...	$\bar{1}\cdot6$	·0043	$\bar{7}\cdot6$	·0128	$\bar{19}\cdot2$	·0200	$\bar{6}\cdot8$	·0111
Glasgow ...	$\bar{29}\cdot5$	·0248	$\bar{120}\cdot0$	·0510	$\bar{71}\cdot3$	·0381	$\bar{49}\cdot8$	·0324
Govan ...	$\bar{16}\cdot9$	·0176	$\bar{34}\cdot0$	·0265	$\bar{2}\cdot2$	·0064	$\bar{3}\cdot4$	·0078
Linlithgow ...	$\bar{6}\cdot2$	·0114	$\bar{7}\cdot7$	·0120	$\bar{3}\cdot4$	·0075	$\bar{1}\cdot4$	·0042
Orkney ...	$\bar{2}\cdot2$	·0069	$\bar{5}\cdot9$	·0100	$\bar{9}\cdot0$	·0118	$\bar{6}\cdot5$	·0108
Perth ...	$\bar{10}\cdot5$	·0142	$\bar{7}\cdot4$	·0124	$\bar{3}\cdot0$	·0072	$\bar{2}\cdot4$	·0063
Renfrew ...	$\bar{4}\cdot8$	·0089	$\bar{15}\cdot3$	·0180	$\bar{2}\cdot9$	·0080	$\bar{3}\cdot5$	·0077
Ross & Cromarty	$\bar{14}\cdot3$	·0167	$\bar{15}\cdot6$	·0175	$\bar{21}\cdot5$	·0197	$\bar{19}\cdot8$	·0192
Roxburgh ...	$\bar{4}\cdot1$	·0095	$\bar{5}\cdot5$	·0104	$\bar{8}\cdot5$	·0121	$\bar{4}\cdot5$	·0088
Selkirk & Peebles	$\bar{10}\cdot7$	·0139	$\bar{7}\cdot9$	·0118	$\bar{3}\cdot5$	·0074	$\bar{2}\cdot3$	·0064
Shetland ...	$\bar{2}\cdot3$	·0067	$\bar{5}\cdot6$	·0103	$\bar{31}\cdot6$	·0237	$\bar{22}\cdot7$	·0205
Stirling ...	$\bar{2}\cdot8$	·0060	$\bar{3}\cdot9$	·0076	$\bar{1}\cdot8$	·0027	$\bar{1}\cdot9$	·0021
Sutherland ...	$\bar{7}\cdot9$	·0116	$\bar{2}\cdot1$	·0073	$\bar{4}\cdot6$	·0084	$\bar{7}\cdot0$	·0120
Wigtown ...	$\bar{1}\cdot2$	·0052	$\bar{2}\cdot4$	·0067	$\bar{3}\cdot1$	·0078	$\bar{7}\cdot4$	·0118

TABLE XXI.

Divergency in Hair Colour. Districts.

Number of District	Log P		Class		Number of District	Log P		Class	
	Boys	Girls	Boys	Girls		Boys	Girls	Boys	Girls
1	$\bar{3}\cdot58$	$\bar{2}\cdot13$	0	0	*57*	$\bar{5}\cdot52$	$\bar{4}\cdot86$	I	I
2	$\bar{12}\cdot87$	$\bar{7}\cdot32$	III	II	*58*	$\bar{1}\cdot64$	$\bar{1}\cdot88$	0	0
3	$\bar{5}\cdot90$	$\bar{3}\cdot79$	I	0	*59*	$\bar{7}\cdot28$	$\bar{5}\cdot65$	II	I
4	$\bar{2}\cdot46$	$\bar{1}\cdot87$	0	0	*60*	$\bar{4}\cdot73$	$\bar{4}\cdot49$	I	I
5	$\bar{4}\cdot17$	$\bar{4}\cdot24$	I	I	*61*	$\bar{2}\cdot36$	$\bar{4}\cdot51$	0	I
6	$\bar{1}\cdot79$	$\bar{2}\cdot55$	0	0	*62*	$\bar{2}\cdot21$	$\bar{4}\cdot39$	0	I
7	$\bar{1}\cdot19$	$\bar{1}\cdot30$	0	0	*63*	$\bar{1}\cdot02$	$3\cdot19$	0	0
8	$\bar{2}\cdot33$	$\bar{2}\cdot07$	0	0	*64*	$3\cdot48$	$4\cdot47$	0	I
9	$5\cdot42$	$\bar{1}\cdot64$	I	0	*65*	$\bar{2}\cdot11$	$\bar{4}\cdot46$	0	I
10	$\bar{7}\cdot65$	$\bar{4}\cdot50$	II	I	*66*	$\bar{4}\cdot66$	$\bar{6}\cdot06$	I	I
11	$\bar{7}\cdot75$	$\bar{2}\cdot43$	II	0	*67, 68*	$\bar{6}\cdot55$	$\bar{4}\cdot56$	I	I
12	$\bar{4}\cdot29$	$\bar{2}\cdot56$	I	0	*69*	$\bar{2}\cdot26$	$\bar{2}\cdot04$	0	0
13	$\bar{44}\cdot88$	$\bar{146}\cdot66$	VII	VII	*70*	$\bar{7}\cdot06$	$\bar{16}\cdot75$	II	V
14	$\bar{3}\cdot83$	$\bar{3}\cdot18$	0	0	*71, 76*	$\bar{10}\cdot48$	$\bar{5}\cdot38$	III	I
15	$\bar{4}\cdot63$	$\bar{8}\cdot84$	I	II	*72*	$\bar{3}\cdot57$	$\bar{2}\cdot52$	0	0
16	$\bar{2}\cdot58$	$\bar{2}\cdot06$	0	0	*73*	$\bar{1}\cdot32$	$\bar{1}\cdot25$	0	0
17	$\bar{1}\cdot94$	$\bar{2}\cdot97$	0	0	*74*	$\bar{3}\cdot37$	$\bar{6}\cdot91$	0	I
18	$\bar{5}\cdot65$	$\bar{7}\cdot84$	I	II	*75*	$\bar{1}\cdot62$	$\bar{3}\cdot48$	0	0
19, 20, 22	$\bar{1}\cdot54$	$\bar{2}\cdot62$	0	0	*77*	$\bar{7}\cdot43$	$\bar{6}\cdot76$	II	I
21	$\bar{1}\cdot09$	$\bar{2}\cdot95$	0	0	*78*	$\bar{2}\cdot64$	$\bar{1}\cdot13$	0	0
23, 30	$\bar{8}\cdot40$	$\bar{2}\cdot04$	II	0	*79*	$\bar{2}\cdot50$	$\bar{2}\cdot97$	0	0
24	$\bar{8}\cdot01$	$\bar{13}\cdot17$	II	IV	*80*	$\bar{5}\cdot08$	$\bar{10}\cdot45$	I	III
25	$3\cdot60$	$\bar{1}\cdot15$	0	0	*81*	$\bar{1}\cdot10$	$\bar{1}\cdot18$	0	0
26	$\bar{3}\cdot88$	$\bar{8}\cdot19$	0	II	*82*	$\bar{1}\cdot17$	$\bar{1}\cdot03$	0	0
27	$\bar{1}\cdot14$	$\bar{9}\cdot77$	0	II	*83*	$\bar{2}\cdot03$	$\bar{4}\cdot39$	0	I
28	$\bar{9}\cdot05$	$\bar{5}\cdot89$	II	I	*84*	$\bar{4}\cdot46$	$\bar{4}\cdot18$	I	I
29	$\bar{1}\cdot13$	$\bar{2}\cdot40$	0	0	*85*	$\bar{4}\cdot55$	$\bar{6}\cdot84$	I	I
31	$\bar{5}\cdot09$	$\bar{1}\cdot95$	I	0	*86*	$\bar{1}\cdot54$	$\bar{3}\cdot46$	0	0
32, 33	$3\cdot61$	$\bar{2}\cdot06$	0	0	*87*	$\bar{3}\cdot55$	$\bar{7}\cdot86$	0	II
34	$3\cdot02$	$\bar{1}\cdot48$	0	0	*88*	$\bar{14}\cdot73$	$\bar{7}\cdot64$	IV	II
35	$\bar{1}\cdot52$	$\bar{1}\cdot89$	0	0	*89*	$\bar{3}\cdot54$	$\bar{1}\cdot34$	0	0
36	$\bar{1}\cdot36$	$\bar{8}\cdot32$	0	II	*90*	$\bar{3}\cdot72$	$\bar{8}\cdot52$	0	II
37	$\bar{7}\cdot09$	$\bar{8}\cdot67$	II	II	*91*	$\bar{14}\cdot45$	$\bar{12}\cdot61$	IV	III
38	$\bar{5}\cdot16$	$\bar{3}\cdot20$	I	0	*92*	$\bar{2}\cdot52$	$\bar{3}\cdot92$	0	0
39	$\bar{1}\cdot35$	$\bar{2}\cdot33$	0	0	*93, 94*	$\bar{6}\cdot75$	$\bar{8}\cdot16$	I	II
40	$\bar{5}\cdot26$	$\bar{4}\cdot49$	I	I	*95*	$\bar{10}\cdot65$	$\bar{3}\cdot23$	III	0
41	$\bar{5}\cdot06$	$\bar{3}\cdot01$	I	0	*96*	$\bar{7}\cdot56$	$6\cdot86$	II	I
42	$\bar{7}\cdot01$	$\bar{7}\cdot69$	II	II	*97*	$\bar{17}\cdot15$	$\bar{10}\cdot85$	V	III
43	$\bar{1}\cdot05$	$\bar{3}\cdot62$	0	0	*98*	$\bar{3}\cdot10$	$\bar{2}\cdot77$	0	0
44	$\bar{3}\cdot78$	$\bar{1}\cdot08$	0	0	*99*	$\bar{14}\cdot78$	$\bar{15}\cdot76$	IV	IV
45	$\bar{5}\cdot51$	$\bar{4}\cdot92$	I	I	*100*	$\bar{11}\cdot10$	$\bar{19}\cdot11$	III	VI
46	$\bar{2}\cdot03$	$\bar{6}\cdot95$	0	I	*101*	$\bar{5}\cdot83$	$\bar{3}\cdot98$	I	0
47	$\bar{2}\cdot06$	$\bar{15}\cdot87$	0	IV	*102*	$\bar{15}\cdot65$	$\bar{4}\cdot99$	IV	I
48	$4\cdot72$	$\bar{2}\cdot00$	I	0	*103*	$\bar{2}\cdot56$	$\bar{4}\cdot93$	0	I
49	$\bar{6}\cdot01$	$\bar{8}\cdot06$	I	II	*104*	$\bar{5}\cdot17$	$\bar{1}\cdot12$	I	0
50	$\bar{3}\cdot18$	$\bar{1}\cdot89$	0	0	*105*	$\bar{7}\cdot91$	$\bar{12}\cdot67$	II	III
51	$\bar{3}\cdot80$	$\bar{3}\cdot14$	0	0	*106*	$\bar{3}\cdot47$	$\bar{4}\cdot45$	0	I
52	$\bar{7}\cdot34$	$\bar{16}\cdot33$	II	V	*107*	$\bar{2}\cdot23$	$\bar{3}\cdot88$	0	0
53	$\bar{3}\cdot02$	$\bar{5}\cdot48$	0	I	*108*	$\bar{3}\cdot87$	$\bar{3}\cdot79$	0	0
54	$\bar{1}\cdot02$	$\bar{4}\cdot73$	0	I	*109*	$\bar{2}\cdot23$	$\bar{5}\cdot88$	0	I
55, 56	$\bar{4}\cdot63$	$\bar{6}\cdot53$	I	I	*110*	$\bar{2}\cdot31$	$\bar{5}\cdot62$	0	I

Scale of Divergency classes is given on the Divergency Maps (Maps XLIII. *et seq.*).

TABLE XXII.

Divergency in Eye Colour. Districts.

Number of District	χ^2		Class		Number of District	χ^2		Class	
	Boys	Girls	Boys	Girls		Boys	Girls	Boys	Girls
1	7·8	2·3	0	0	*57*	58·2	55·6	III	III
2	189·7	76·2	VII	V	*58*	7·3	3·5	0	0
3	18·7	24·2	I	I	*59*	49·2	17·8	III	0
4	5·2	22·2	0	I	*60*	21·5	20·9	I	I
5	10·9	7·7	0	0	*61*	37·8	34·5	II	II
6	63·4	51·7	IV	III	*62*	19·8	21·8	I	I
7	25·9	11·3	I	0	*63*	13·9	4·4	0	0
8	43·3	21·9	II	I	*64*	35·0	38·2	II	II
9	40·9	32·2	II	I	*65*	38·8	23·2	II	I
10	18·4	6·0	I	0	*66*	40·3	53·2	II	III
11	31·6	44·5	I	II	*67, 68*	44·2	38·4	II	II
12	37·9	45·7	II	II	*69*	22·4	15·3	I	0
13	270·0	198·5	VII	VII	*70*	39·0	60·5	II	III
14	7·3	3·7	0	0	*71, 76*	25·8	23·3	I	I
15	42·6	30·7	II	I	*72*	7·0	9·5	0	0
16	19·4	27·9	I	I	*73*	5·7	21·3	0	I
17	10·2	18·2	0	0	*74*	2·4	14·2	0	0
18	10·9	17·4	0	0	*75*	11·9	7·7	0	0
19, 20, 22	29·1	47·2	I	II	*77*	32·3	16·2	I	0
21	4·9	17·0	0	0	*78*	23·5	25·0	I	I
23, 30	56·5	42·5	III	II	*79*	28·4	25·7	I	I
24	5·9	3·6	0	0	*80*	53·4	57·9	III	III
25	13·1	9·8	0	0	*81*	18·9	14·6	I	0
26	19·5	29·9	I	I	*82*	13·4	6·6	0	0
27	17·3	14·4	0	0	*83*	49·1	16·0	III	0
28	32·9	45·4	I	II	*84*	20·4	9·4	I	0
29	56·0	45·9	III	II	*85*	36·0	51·9	II	III
31	9·2	4·5	0	0	*86*	9·2	30·1	0	I
32, 33	24·3	42·1	I	II	*87*	12·6	15·6	0	0
34	12·9	20·3	0	I	*88*	107·4	74·8	VI	IV
35	52·4	25·1	III	I	*89*	18·8	13·7	I	0
36	17·8	26·6	0	I	*90*	83·6	13·4	V	0
37	12·6	7·3	0	0	*91*	55·5	60·2	III	III
38	9·3	8·4	0	0	*92*	21·0	15·0	I	0
39	56·7	17·1	III	0	*93, 94*	124·8	112·3	VII	VII
40	45·0	21·6	II	I	*95*	7·5	1·7	0	0
41	8·0	8·2	0	0	*96*	43·7	59·7	II	III
42	17·7	15·0	0	0	*97*	25·0	·7	I	0
43	27·7	16·2	I	0	*98*	1·6	7·1	0	0
44	40·6	20·4	II	I	*99*	24·8	39·0	I	II
45	80·2	85·1	V	V	*100*	15·7	6·3	0	0
46	9·1	1·8	0	0	*101*	24·7	13·8	I	0
47	44·4	23·5	II	I	*102*	79·1	35·2	V	II
48	44·2	12·9	II	0	*103*	24·4	4·1	I	0
49	42·2	39·9	II	II	*104*	15·3	12·2	0	0
50	13·3	23·0	0	I	*105*	31·7	26·2	I	I
51	12·5	17·6	0	0	*106*	35·9	47·8	II	III
52	10·6	26·0	0	I	*107*	10·7	34·5	0	II
53	7·0	11·4	0	0	*108*	50·2	47·8	III	III
54	13·9	6·0	0	0	*109*	35·5	28·9	II	I
55, 56	6·2	19·5	0	I	*110*	144·0	102·0	VII	VI

TABLE XXIII.

Counties considered	Persons per Square Mile
Average Density of Population in non-divergent counties (Boys) ...	291
" " " " (Girls) ...	263
Average Density of Population, taking the 33 counties of Scotland ...	256

sample of the whole country. If, however, there were special causes leading persons belonging to one or more of the colour classes to congregate in certain areas to the exclusion of others, the groups in the densely populated areas would tend to diverge from the form of distribution found to hold for the whole country. The densely populated counties of Forfar, Fife, Stirling, Dumbarton and Lanark (excluding Glasgow), are fair samples of the boy population, and therefore in these densely populated areas no special causes are likely to be found to exist tending to change the distribution of hair colour. The same can be said of the girl populations of Forfar, Stirling and Dumbarton. But the still denser centres, namely the great cities, are different, excepting Edinburgh, which is quite like the general population, for both boys and girls. The cities of Aberdeen, Dundee and particularly Glasgow, densely populated centres, diverge largely from the general population, for some reason or other. What special cause or causes are in operation which make the chief cities, excepting Edinburgh, unrepresentative? Two suggest themselves. (1) One would expect great seaports to differ if foreigners and others (Irish, etc.) of non-Scottish origin, who on an average differed in their colour characters from the general Scottish distribution, settled in these places. (2) Another special cause would clearly exist in the case where a country population contiguous to a large town differed largely from the general population, their influx thereby changing the character of the town population—a population which otherwise should be a fair representation of the whole country. It will be seen in a later section that the facts support the foregoing propositions at least in the special case of Greater Glasgow, which contains within its bounds one-fifth of the whole population of Scotland.

(γ) Divergency in hair colour in district groups will now be briefly considered. It has just been stated that of the great cities Glasgow stands out as by far the most divergent, Aberdeen, Dundee and Leith following, while Edinburgh is quite passably a sample of the general population and is thus for hair colour a representative sample of all parts of Scotland. Kirkcaldy, Perth, Inverness, Ayr, Kilmarnock, Montrose, Stirling, and other smaller towns moderately resemble the general population. Examining now the country districts, it is seen that by far the most divergent area is along the seaboard of the west (see Maps XLVII. and XLVIII.). This area contributes largely to the divergency of the north-west by its blackness, darkness and fairness, as revealed by the division and county analyses, and has the following boundaries. It commences in the north-west of Ross, is

bounded by Strath Glass eastward, includes Skye in the west and terminates in Islay and Jura for boys and Mull for girls. This is of course the heart of the Gaelic speaking region. The region of the Caledonian Canal is less divergent than the west, but passing over to Perthshire, East Inverness due again to excess of fair and jet black, and Moray due to fair, the divergency increases. The divergency of the population eastward of this diminishes but it is still high in Donside in Aberdeenshire. Travelling southwards, it again reaches a maximum in the region of Dunkeld and eastward towards the coast, but excluding it, due again to blackness and fairness. As already pointed out in the county groups, the east coast is not very divergent, Fife being the most divergent portion of the coast-line. The region around Dunfermline, due to a large excess of fair, is widely divergent, as also is Midlothian from the same cause. Berwick, north of the Tweed, is a divergent population, but Roxburgh, south of the Tweed, is very like the general population. From Berwick the divergency follows the Tweed and passing through Selkirk and Peebles reaches the Solway Firth, where it again turns in a north-western direction (♀), avoiding Galloway which, as has been already pointed out, passably resembles the general population. The divergency (♀) maintains the same degree in Ayr (north) as in Dumfries, but excepting a portion south of Ayr burgh the whole of the south-west population of boys is fairly homogeneous.

As shown by the district grouping the local populations of boys which passably resemble the general population, are the regions of West Caithness, the south coast of the Moray Firth, excepting Elgin, the Deveron Valley, the Ythan valley, Deeside, Kincardineshire, the south-west of the Firth of Forth, the south-east of Fife, the Lothians, the Teviot valley and the south-west of Scotland—that is, west of Peebles and Dumfries, and south of Renfrew and North Lanark. Speaking generally of the boy population, the populous area commencing in the north-east and ending in the region of Glasgow, i.e. in the northern portion of the south-west (including most of the intervening area), is the least divergent area for boys. The north-west and south-east are the most divergent—the north-west mainly because of its darkness, and the south-east mainly because of its fairness.

The divergency of the girl population is different in some respects. Only a small portion of the coast near Inverness is non-divergent instead of the larger tract for boys. The Lothians, a considerable portion of Dumfries, the northern part of Kirkcudbright and Ayr north of the burgh are all more divergent than the boy population and do not passably resemble the general population as the corresponding groups for boys do. The northern portion of Argyll and the southern portion of Inverness are non-divergent girl populations, the corresponding boy populations being much more divergent. On the whole the non-divergent girl groups are more isolated from one another than the boy groups, and the separation of the population (excluding certain towns) diagonally into an east-north-east and midland non-divergent population and a west-north-west and east-south-east divergent one is not so apparent. In a general way one can see that the district groups confirm the results of the county analysis. One can see from the district

TABLE XXIV. *Divergency in Hair Colour.*

Not Significant or Scarcely Significant. Class 0	Probably Significant or Quite Significant. Classes I and II		Widely Divergent. Classes III and upwards	
Division	Division	Divergence is mainly due to excess of	Division	Divergence is mainly due to excess of
East-Midland	North-Eastern (♂)	fair, red	Northern	fair, jet black, dark (♂)
Southern (♂)	West-Midland (♀)	dark, jet black	North-Western	fair, dark, jet black
			South-Eastern	fair, red (♂) medium (♂)
			South-Western	medium, dark
			North-Eastern (♀)	fair, red
			West Midland (♂)	dark, jet black
			Southern (♀)	fair
County	County		County	
Orkney & Shetland (♂)	Orkney & Shetland (♀)	fair	Fife (♀)	fair
Aberdeen (♂)	Aberdeen (♀)	red, jet black	Banff (♀)	fair, red
Kincardine (♂)	Kincardine (♀)	fair	Selkirk (♂)	medium, red
Forfar	Lanark (♀)	fair	Peebles (♂)	medium, red
Fife	Caithness (♂)	fair, jet black	Ross & Cromarty	fair, dark, jet black
Stirling	Kirkcudbright (♂)	red		
Dumbarton	Bute (♂)	medium, jet black	Inverness	jet black, dark, fair
Lanark (♀)	Sutherland (♂)	dark, jet black		
Wigtown	Elgin	fair	Argyll	dark, jet black
Haddington	Banff (♂)	fair, red	Perth (♂)	fair, jet black
Caithness (♀)	Aberdeen City	red, dark	Glasgow	medium, dark
Kirkcudbright (♀)	Dundee	medium, dark, black	Govan	medium
Bute (♀)	Leith	medium		
Sutherland (♀)	Berwick	fair, medium		
Edinburgh City	Roxburgh	fair		
	Dumfries	fair, medium		
	Ayr	fair		
	Selkirk (♀)	medium, red		
	Peebles (♀)	medium, red		
	Perth (♀)	fair, jet black		
District or Area	District or Area		District or Area	
Caithness inland	Banff and Aberdeen Coast		Seaboard on west coast from Sutherland to Mull, bounded by Strath Glass and Caledonian Canal eastwards	dark, jet black (fair slightly)
Lower Spey, Findhorn & Deveron Valleys, except Elgin	The district parallel eastward to the Caledonian Canal (♂)			
Deeside	Upper Tweeddale, Ettrick and Yarrow region			
Kincardine coast	Leith			
Esk Valleys	Hamilton			
Loch Earn	Dundee			
Falkirk region (♂)	Central Buchan		Caithness Seaboard to Black Isle	fair, dark, jet black
Haddington coast	Stirling		Upper Spey and Findhorn Valleys	fair
Teviotdale	South Forfar		Region South of the Forest of Athol	fair, jet black
Galloway & Clyde Valley to Ayr Coast (♂)	Loch Leven district			
Galloway & South Ayr (♀)	South-East Fife		Donside (♀)	fair
Upper Spey region parallel to Caledonian Canal, eastwards & northern portion of Argyll (♂)	Selkirk		Dunkeld region	fair, black
			Dunfermline region	fair
			Glasgow	dark, medium
Towns :—Edinburgh			Greenock	dark
Kirkcaldy				
Perth				
Inverness				
Ayr				
Kilmarnock				
Montrose				
Stirling				

maps (XLVII. and XLVIII.) that the denser midland and east coast areas are well mixed samples of the population. Over the whole of Scotland about 60 of the separate district groups are quite representative of the general population, representing a total of 114,482 boys in the boy population of 257,766, or 44·4 per cent., and 97,839 girls in the girl population of 244,389, or 40 per cent.

The results of the divergency analysis for hair colour can now be summarised. Taking large samples of the population (i.e. the divisions) to remove merely local differences and to some extent the effect of unequal density, thus getting a general view, it is seen that the populous East-Midland division is a fair representation of the general population for hair colour of both boys and girls. The Southern division is so for girls only. The fairly populous North-Eastern division diverges mainly because of its fair-haired and red-haired population; the less populous West-Midland division because of its dark population. The other divisions are widely divergent for several reasons. The divergencies of the Northern and North and North-Western divisions are accentuated by their being comparatively small samples separated geographically from the rest of the population, and are not like the rest of the country because of their excessive fairness and darkness.

Taking smaller samples of the population (counties, cities and districts) it is seen that populous counties are fairly representative of the general population; many populous districts also are; but the great cities (excluding Edinburgh which is representative of the population) are divergent. There are elements present in the urban populations which make them unrepresentative of the general population. Certain outlying sparsely populated districts, particularly on the west coast, are also divergent and unrepresentative. The cause or causes of the divergency in the populations affected will be considered in the next section.

III. *Eye Colour.* (α) *Divisions.* The Southern and South-Eastern divisions (♂ and ♀) are the most representative of the general population. These populations are passable samples of the general population. Next in order are the North-Eastern, East-Midland and West-Midland divisions. Then follow the Northern—due to excess of blue eyes, and the South-Western—due to excess of medium and dark; and lastly the most divergent of all, the North-Western, whose divergency is also mainly due to the excess of blue eyes. (See Maps XLIX. and L.)

(β) *Counties.* Examining the county divergencies it is seen that, in the boy population, and taken in the order of greatest divergency to least divergency, the following counties diverge greatly from the general population owing to excess of blue eyes, namely: Orkney, Shetland, Ross, Cromarty, Inverness, Elgin, Nairn, Aberdeen and Forfar. Ayr in the south greatly diverges owing to excess of both blue and light eyes, and Lanark greatly diverges owing to a large excess of medium eyes. The divergencies in all the foregoing cases are very great. Among the still significantly but less divergent counties are the Lothians and Roxburgh (excess of blue eyes), Dumfries (excess of light and medium), Argyll and Dumbarton perhaps (excess of light eyes). The non-divergent regions are somewhat isolated from one another; they are Banff and Kincardine in the north; Perth, Fife, Stirling,

Dumbarton, Renfrew and Linlithgow, all contiguous—that is, practically the whole of the Scottish Midlands; Berwick, Peebles and Selkirk, contiguous in the south-east, and finally Kirkcudbright and Wigtown in the south.

The girl population shows on the whole equal divergencies in the northern counties already mentioned, divergencies which are due to excess of blue eyes; in Ayr the divergency is almost entirely due to blue eyes and scarcely any to light eyes as among the boy population. The divergency in Lanark is only just significant and is due to excess of both medium and light eyes. Wigtown and Kirkcudbright are both significantly divergent, due in the case of Wigtown to excess of blue eyes and in the case of Kirkcudbright to excess of light eyes. Galloway therefore differs distinctly in its boy and girl distributions of eye colour. The non-divergent regions or rather the non-significantly divergent regions in the girl population for eye colour are as follows: Caithness and Banff in the north; Perth, Linlithgow, Stirling, North Lanark and Renfrew all contiguous; and Berwick, Selkirk and Peebles also contiguous near the Border.

(γ) *Districts.* Looking at the district results, they confirm the county analysis and also the conclusions arrived at with respect to hair colour. The populous Midlands, namely, North Lanark, Perth, Stirling, Dumbarton, Fife and portions of the east coast (i.e. Forfar and north-east Aberdeenshire, and from Nairn to Caithness) are all comparatively representative of the general population in eye colour. Thus while Glasgow itself is divergent, the great part of the environs is not. Such populous centres as Greenock, Kilmarnock, Falkirk, Ayr, are scarcely significantly divergent. Edinburgh, Dundee and Aberdeen cities are significantly divergent. In Aberdeen it is due to excess of medium, in Dundee to excess of dark and medium and in Edinburgh to excess of dark alone. It is seen, just as in hair colour, that the very sparsely populated regions and the very thickly populated areas are the most divergent. But while all the sparsely populated regions diverge on account of excess of blue eyes, all the very densely populated areas diverge because of excess of light, medium or dark. It is to be expected that Dundee would have a fair proportion, or even excess, of dark eyes, since the country adjacent to the city, namely, Perthshire and Forfarshire, are the only counties in Scotland showing excess of this class. The reason for the excess in Edinburgh is not so apparent, unless the migration from these counties to the capital is greater than from the rest of the country. The foreign population, as will be shown later, is significantly associated in general with dark eyes, but on examining the returns, it has been found that foreigners are not present in Edinburgh in sufficient numbers to affect the distribution of dark eyes in the school population there. With Glasgow or certain districts of the western city, the case is different, as will presently be shown. Forfarshire and Perthshire people are perhaps likely to have migrated to Edinburgh in greater numbers than people from other parts. This would account for the excess. The excess of medium eyes in Glasgow may be partly accounted for by a greater proportion of migrants from Lanarkshire, Dumfries, Peebles, Selkirk and Fife, all counties with a distinct excess of this class.

TABLE XXV.

Divergency in Eye Colour.

Not Significant or Scarcely Significant. Class 0	Probably Significant or Quite Significant. Classes I and II		Widely Divergent. Classes III and upwards	
Division	**Division**	**Due to Excess of**	**Division**	**Due to Excess of**
South-Eastern	Northern	blue	North-Western	blue
Southern	North-Eastern	medium & blue	South-Western	medium
	East-Midland	dark & blue		
	West-Midland	light		
County	**County**	**Due to Excess of**	**County**	**Due to Excess of**
Banff	Sutherland	blue, dark	Shetland	blue
Caithness	Aberdeen	blue, medium	Ross & Cromarty	blue
Kincardine	Argyll	light	Inverness	blue
Perth	Dumbarton	light	Elgin & Nairn	blue
Stirling	Midlothian	blue	Forfar	blue & dark
Dumbarton	Roxburgh	blue (and dark)	Lanark (♂)	medium
Govan	Dumfries	light	Ayr	blue & light
Renfrew	Orkney	blue	Glasgow	medium & dark
Linlithgow	Aberdeen City	medium	Leith	light & medium
Selkirk	Dundee City	medium & dark		
Peebles	Edinburgh City	dark		
Berwick				
Kirkcudbright				
Wigtown				
Bute				
Haddington				
Fife				
Kinross & Clackmannan				
District or Area	**District or Area**		**District or Area**	**Due to Excess of**
Environs of Glasgow	Parts of North Lanark and North Ayr		North-East Lanark, Carluke region	blue
Renfrew including Greenock	Midlothian except near Edinburgh		Elgin district	blue
Kilmarnock	South Fife (♀)		Spey Valley	blue
Ayr	Dundee		Black Isle	blue
Parts of North Lanark	Most of Perthshire		Glen Urquhart region	blue
Falkirk area	Edinburgh City		Islay & Jura	light
Environs of Edinburgh	Aberdeen City		Shetland	blue
Fifeshire generally except Loch Leven area	Galloway		Glasgow	medium & dark
North Forfar	Linlithgow area			
Area from Buchan coast to Spey Valley	Skye and the adjacent mainland, north and south			
Dornoch and Tain region	Orkney			
Caithness inland	Remaining environs of Glasgow			
North and South Uist	Irvine			
	Roxburgh			
Mull and adjacent mainland	Outskirts of Perth city			
South Ayrshire	Donside			
Dumfries	Part of Buchan coast			
North Kirkcudbright	Lewis			
South Roxburgh	North Dumbarton			
Peebles				
Berwick				

Whether migrants from these counties partly account for the excess of medium eyes in Glasgow or not, excess of medium eyes is associated with densely populated centres and is accordingly dealt with in the section discussing the relationship between density of population and colour. It should be finally noted that the very sparsely populated regions, all of them having an excess of blue eyes, are inhabited by a people who have been undisturbed by any recent immigrations and who most probably are descendants of a race long resident in the country.

The accompanying table (Table XXV.) gives a synopsis of the results respecting the relative divergency in eye colour, in the divisions, counties and districts respectively.

(8) *Class Segregation. The Nature of the Distribution of Relative Local Differences of each Class considered collectively and interlocally, without reference as to where they occur geographically, and the Degree of Segregation of each Class determined.*

I. *Interlocal Constants.* It has been shown (Section 6) that, in each colour class, differences occur throughout the country in localities (specifically pointed out, in each case, in the section referred to), which are distinctly significant. Positive differences, much in excess of the expected, occur in contiguous areas, indicating a differentiation for each class more or less from the remaining population. That is, the existence of these individual local differences proves that the population is not an evenly distributed one with respect to the colour class or classes under consideration. It is true that many of the differences could quite well occur at random and therefore that many localities resemble the general population with respect to one or more classes. But those larger differences, reckoned significant owing to the great odds against their occurring at random, quite upset the proposition that the distribution of the class over the whole country is a random one. Having indicated the localities where individual significant differences occur (thus proving segregation) and also those where non-significant differences occur, the differences for each class collectively will be considered without reference as to where they occur geographically in order to compare the *degrees* of segregation of the classes. It will then be seen which class has the greatest geographical separation. It is therefore necessary to provide a *measure* of local segregation, that is to say, one must have a single common measure, for each class, of the extent of the deviation from a uniform distribution of persons belonging to the class over the whole country. This measure is easily obtained when it is remembered that the relative local differences are all the local differences reduced to a common scale by dividing each difference by its standard deviation. Since this is the case, if the differences are such as would arise from a uniform distribution of the persons belonging to each class all over the country, these differences as a series would of course form a normal distribution with a mean value $h = 0 \pm \frac{\cdot 67449}{\sqrt{q}}$, and a standard deviation $s = 1 \pm \frac{\cdot 67449}{\sqrt{(2q)}}$, where q is the number of groups (either counties, districts, or units of area) considered. Thus

h and s are interlocal constants. This test of the degree of homogeneity of a class or character in a population scattered over a wide area has already been applied by the writer, the constants for both measurable and non-measurable characters being determined*. If then a population is non-segregated with respect to any class (that is, if persons belonging to the class are well distributed over the country) the interlocal constants h and $(s-1)$ will be both equal to zero within the limits of their probable errors, and the segregation of a class will increase as these constants become greater and greater.

The following table (Table XXVI.) gives the values of the interlocal constants for both the boy and girl populations, the distributions considered being those of the relative local differences arrived at from the county data—that is, with the county as the unit of area. Table XXVII. is one in which the classes are arranged in the order of the significance from lesser to greater segregation.

II. *Significance of the Constants.* These results show how decided the deviations are from purely uniform distributions of the class populations. It is seen that the blue-eyed class and the fair-haired class are both highly separated geographically from the general population. The separation is greater in the case of fair-haired girls than in the boys of the same class. The deviation from a random distribution for boys and girls is of the same order in the other colour classes.

TABLE XXVI.

Interlocal Constants. Colour Segregation.

(This table shows that a grouping of children of the same class occurs no matter what class is selected. The figures show the relative extent of the segregation of the classes.)

h=mean of the series of relative local differences, boys or girls, for each colour class.

s=standard deviation of the series of relative local differences, boys or girls, for each colour class.

s_m=standard deviation, as above (boys).

s_f=standard deviation, as above (girls).

Colour	Boys			Girls			
	h	$(s-1)$	$\frac{s-1}{E_{(s-1)}}$	h	$(s-1)$	$\frac{s-1}{E_{(s-1)}}$	$s_m - s_f$
Fair Hair ...	·45	2·75	34·12	1·14	5·14	63·77	−2·39
Red Hair ...	·18	·69	8·56	·09	·56	6·95	·13
Medium Hair ...	− ·57	2·82	34·86	− ·81	2·90	35·98	− ·09
Dark Hair ...	− ·04	2·24	27·79	− ·39	2·95	36·60	− ·71
Jet Black Hair ...	·20	1·36	16·87	·32	1·93	23·95	− ·57
Blue Eyes ...	1·17	5·02	62·28	1·02	4·12	51·12	·90
Light Eyes ...	− ·09	1·78	22·08	·13	1·85	22·95	− ·07
Medium Eyes ...	− ·51	2·09	25·93	− ·59	2·15	26·68	− ·06
Dark Eyes ...	− ·33	2·11	26·18	− ·35	1·87	23·20	·24

* *Biometrika*, Vol. v. pp. 323—327.

Red hair is the only class which shows a moderate approach to uniformity of distribution, but even in this class the deviations are 7 and $8\frac{1}{2}$ times their probable errors for boys and girls respectively. There is, however, a decided approach towards an even distribution of this class over the whole country compared with all the other classes. But for the probably significant excesses in the north-east

TABLE XXVII.

Segregation in Colour.

(This table shows that children with red hair are the most uniformly distributed class, while fair haired blue eyed children are not well distributed throughout the country. They have a tendency to occur in groups and show therefore the greatest segregation.)

Divergence from homogeneity is	Interlocal constant is	Class of Category
Significant ...	between 0 and 1·0	Red Hair ♂ and ♀
Very significant ...	„ 1·0 and 2·0	Jet Black Hair ♂ and ♀ Light Eyes ♂ ♀ Dark Eyes ♀
Highly significant ...	„ 2·0 and 3·0	Dark Eyes ♂ Medium Eyes ♂ ♀ Dark Hair ♂ and ♀ Fair Hair ♂ Medium Hair ♂ ♀
Excessively great ...	above 3·0	Fair Hair ♀ Blue Eyes ♂ ♀

of Scotland and the neighbourhood of Edinburgh as shown in the class analysis (Section 6), the distribution of the class of red-haired persons would be fairly uniform. The chance against meeting a schoolboy of this class in travelling over Scotland is about 17 to 1. One would have to note at random the colour characters of at least 18 people on an average in order to have one of this class in the group. But the chances are slightly lower in Aberdeen and Banff and Midlothian. They fall to about 14 to 1 against. The chance against meeting a person of the jet black class is much smaller, about 99 to 1, but the chances vary more as one moves from place to place. In certain places it is as small as 400 to 1. The chance against meeting a person of the dark class or of the fair class is about 3 to 1 and of the medium class about 3 to 2 and so on. The point is that while one can state in a general way the chances for or against a Scottish child belonging to any one of the hair and eye colour classes, these chances vary largely from district to district. The question may be asked, What is the typical Scotchman like? One cannot answer that question offhand from the present data, which deals with school children only. It must be remembered that there is a change in hair colour and eye colour in passing from childhood to manhood. Hair colour generally becomes darker more or less with age. A fair-haired boy or girl may or may not become a fair-haired man or woman, but there is a tendency to become darker. A measure of the change, from Prussian and British data by Pearson*, and by the author† from the Aberdeenshire data, shows

* Pearson: *Biometrika*, Vol. III. p. 161.

† *Biometrika*, Vol. V. pp. 339—341.

that the correlation between age and hair colour is quite appreciable. On the assumption that the rate of change of hair colour and eye colour with age is not likely to vary appreciably in passing from one district to another, the author determined the probable distribution of the colour of the adult population of Scotland. The result was published in the same memoir*. Using the result together with the percentage results for the whole of Scotland for boys and girls as found from the present data, the following table (Table XXVIII.), constructed as a probability table, gives the chance of a person of Scottish nationality possessing any one of the following characteristics :—

TABLE XXVIII.

The Probability of the Person belonging to any one of the following Colour Classes is

Colour	Adult Population	Boys			Girls		
		Scotland Generally	Range in Counties		Scotland Generally	Range in Counties	
			From	To		From	To
Hair:							
Fair ...	·115	·250	·221	·314	·274	·243	·344
Red ...	·042	·055	·046	·069	·051	·041	·068
Medium ...	·559	·433	·373	·495	·409	·356	·474
Dark } ...	·284	·250	·187	·308	·254	·194	·291
Jet Black } ...		·013	·008	·024	·012	·002	·026
Eyes:							
Blue } ...	·278	·147	·103	·259	·148	·118	·252
Light } ...		·303	·227	·337	·303	·241	·348
Medium ...	·459	·327	·279	·344	·321	·266	·358
Dark ...	·263	·223	·174	·244	·228	·159	·263

With regard to the juvenile population, the above table shows that one can hardly say any particular eye colour is typical of Scotland. There is a bias in favour of light and medium eyes. Brown hair is the most likely colour for a child to possess. Fair and dark are equally likely hair colours in the juvenile population. Medium eyes and brown or medium hair are more typical of the adult population.

Summarising the results of this section, it has been found possible to classify the degrees of segregation of the colour classes—a segregation already proved, although its amount was not revealed in any one case in considering the individual differences. It has now been shown that segregation of certain classes from others exists. The greatest segregation from others (or congregation as a class) is shown

* Tocher: *Biometrika*, Vol. v. pp. 339—341.

in the case of blue eyes, the interlocal or segregation constants $(s-1)$ being 5·02 and 4·12 respectively (see also Diagrams VI. and XV.). The odds against an even distribution of persons belonging to this class is thus enormously great, as also are the odds against persons of the fair-haired class being evenly distributed (see Diagrams I. and X.). The difference in the segregation of the boys and girls is marked. Medium hair and dark hair are approximately equal to fair hair (♂) in their divergence from uniformity of distribution (Diagrams III., IV., XII. and XIII.), and then follow medium and dark eyes (Diagrams VIII., IX., XVII. and XVIII.), and with slightly less segregation still, light eyes (Diagrams VII. and XVI.), and jet black hair (Diagrams V. and XIV.). Finally, in the case of red hair the interlocal constant shows persons belonging to this class to be the most evenly distributed one throughout the country (Diagrams II. and XI.). In no case, however, can the exact probability of an individual belonging to any particular class be predicted with accuracy, just on account of the uneven nature of the distribution of persons belonging to the class. It falls finally to be noted here that the differences for each class have been considered collectively, without reference as to *where* they occur geographically or as to whether the differences for boys and girls occur together in the same place. This point is specially dealt with in another section, where a measure is given of the agreement of the sexes in colour characters.

The most striking result in this section is that bearing on red hair. Its distribution is so markedly different from the rest of the classes as to attract attention. The occurrence of red hair in Scotland either (α) is independent of race, or (β) is one of the effects of blending of races—perhaps widely divergent races, or (γ) is an abnormal condition in hair colour and deserves the attention of the physiologist and pathologist.

(9) *Peculiarities in the Distribution of Colour in Scotland.*

I. *General.* An examination of Table XXIX. will show how far the distribution for boys and girls differ, and also what excesses for hair colour and eye colour occur together. It should be noted that this does not necessarily mean that a particular combination (e.g. fair hair and blue eyes) is in excess. This can be accurately determined only by comparing the excess frequencies of the particular combinations found in the localities under consideration with the proportional frequencies of the same combinations in the general population. The statistical labour involved in such an analysis would be very great and could not be attempted by the writer until the present analysis had been completed. Besides, no funds were available to defray the considerable additional expense which would have been incurred in providing for clerical assistance in tabling the combinations and otherwise completing the statistical analysis. Thus, the results of the present investigation are those flowing from individual classes and only indirectly from combinations.

The table (Table XXIX.) shows that in the girl population of the entire north, excess of blue eyes and fair, dark and black hair occurs together. Excess of blue eyes, although common to the entire north for the boy population, is associated with great excess of fair hair only in the North-Western division, and with excess of red hair in the North-Eastern division, which excess is also

TABLE XXIX.

Excess positive Frequencies peculiar to each of the eight great Divisions of Scotland.*

B = Boy Population. G = Girl Population.

Colour	Division							
	I	II	III	IV	V	VI	VII	VIII
Hair:								
Fair ...	BG	BG	BG	G	—	—	BG	BG
Red ...	—	—	BG	—	—	—	B	—
Medium ...	—	—	—	B	—	BG	B	—
Dark ...	B	BG	—	—	BG	G	—	—
Jet Black ...	BG	BG	—	—	BG	—	—	—
Eyes:								
Blue ...	BG	BG	BG	B	—	—	—	B
Light ...	—	—	—	—	BG	B	BG	BG
Medium ...	—	—	BG	—	—	BG	—	—
Dark ...	—	—	—	BG	—	BG	—	—

characteristic of the girl population in that division. The characteristic feature of the East-Midland division is that it possesses both an excess of blue eyes and an excess of dark eyes. There is an excess of fair hair (♀), and a defect of red hair (♂), but otherwise the hair distribution does not markedly differ from the general population. The West-Midland population differs quite sensibly from the East-Midland. The characteristic feature of the West-Midland population is that excess of light eyes occurs with excess of both dark and jet black hair. The South-Western division with its dense urban populations is quite different from the Southern and South-Eastern divisions. The South-Western population has an excess of medium hair occurring with excesses of medium and dark eyes, while the remaining Southern population is characterised by an excess of fair hair only. The Southern division (♀) has the excess of fair hair occurring with excess of light eyes.

The question may well be asked: What can one learn from all this maze of detail as to the significant differences in the distributions of the various colour classes? Are they racial differences or differences due to other factors? One

* In some cases the excess positive frequencies are not quite significant (see tables of relative differences, Table VII.).

cannot in this memoir enter into a general discussion as to the origin and racial characteristics of the Scottish people. This memoir is concerned only in elucidating the nature of the colour-characteristics of Scottish children for the purpose of assisting those engaged in studying racial and social problems and problems in heredity. Such peculiarities as may assist this study may therefore be noticed in detail.

II. *Red Hair.* A striking peculiarity in the distribution of red hair has already been noted in the last section. The class is almost uniformly distributed throughout Scotland. Three probable causes of its occurrence were stated in the section referred to. Whether any of these are valid must be determined by investigation, but the fact remains that the distribution of the class widely differs from the distributions of the other classes.

The occurrence of red hair is certainly not confined to modern times, neither is it peculiar to any social circle. It has occurred in the past as a becoming feature in princes and among the people. It is an inherited trait in many distinguished families. Is it that here one has a case of exclusive inheritance, and therefore that cases of red hair occurring in families none of the parents of which belong to the class, are reversions? Such observations as have been made point to this conclusion, but a larger mass of data is wanted to prove or disprove this view.

It is a curious circumstance that significant excess of the class should be found occurring in the historic home of the opponents of Agricola. The solitary reference of Tacitus to the red-haired Caledonians who inhabited Scotland north of the Grampians deserves a passing notice. Taking the general impression of Tacitus as indicated in his statement "Namque rutilae Caledoniam habitantiam comae, magni artus, germanicam originem asseverunt" to mean that the northern Scottish people in his time were mostly red-haired in our sense and appeared to have a North European origin, it is perfectly obvious that the North of Scotland has changed most markedly, as one should expect it would have, in the long interval between his time and the present day. Not more than 5·49 per cent. and 5·09 per cent. respectively of the boy and girl populations of Scotland are red-haired. It is curious to note, however, that the greatest excess of red hair from this proportion *is found* in the region of Scotland north of the Grampians. While this is the case one must remember that the actual proportion of red-haired persons anywhere in the north is really a small one. Only a small proportion, ranging from 5 to 7 per cent., taking fairly large areas, is at the present day red-haired. But if the observation of Tacitus has any truth in it at all, is it fair to infer, since hair colour is an inherited character, that this small class has for a considerable portion of its ancestry the race found in North Britain in later Roman times? One must not come to the hasty conclusion that there was in reality an exclusively red-haired race in Scotland or anywhere else. Indeed, no such exclusive race now exists. But at the present time one finds red hair occurring in all the North European races more or less. That is to say, the

English, Irish, French, German, Danish, Dutch, Belgian, Norwegian and Swedish speaking peoples, at least, have all of them certain proportions of the red-haired class in their respective populations. It thus appears that in every Northern race there is likely to be a certain proportion of the red-haired class. A moderate proportion (5 per cent.) is found in Scotland generally, and all one can meantime say therefore is that it is a characteristic of one-seventeenth of the population of the north-east of Scotland to have red hair; or *that that population, observed in early time to have red hair, has a significant excess of that class over the general proportion found in the country at the present time.*

III. *Relationship between Gaelic speaking Population and Pigmentation.* As already indicated, one cannot open a discussion as to the origin, distribution and characteristics of the Keltic and non-Keltic portions of the population. Nothing germane to this investigation would be solved by it. Authorities differ greatly as to the facts. One could by an analysis of the colour characters of the population with respect to surnames, Highland, Lowland and otherwise, throw a little light on that portion of the Keltic problem bearing on colour. This has already been done by the writer for the populations of Aberdeenshire of 1696 and 1896*, and he proposes at some future time to table the data now collected for the whole of Scotland in a similar way. What can be done, however, is to investigate the characters of the Gaelic speaking portion of the population as compared with the non-Gaelic speaking and greater portion, and note whether they are really different or not. Here one is on safe ground. The problem of the ethnic descent of the Gaelic speaking and non-Gaelic speaking portions of the population the writer leaves untouched. But he proposes to note whether there is any particular association of colour with the Gaelic speaking population. In the Report on the Scottish Census of 1901†, the number of "Gaelic and English" speaking persons above three years of age is given for each division of Scotland. The percentages of Gaelic and English speaking persons in the eight divisions of Scotland can thus be found and compared with the corresponding percentages for hair colour and eye colour found from the results of this survey. The correlation coefficients were determined in the following manner:—Let x_1 = deviation from mean percentage of the Gaelic speaking population; x_2 = corresponding deviation from the mean percentage of children belonging to any colour class; σ_1 = standard deviation of percentage of the Gaelic speaking population; σ_2 = standard deviation of the percentage of children belonging to colour class s; and N = number of the divisions into which Scotland is divided; then the correlation coefficient is:

$$r = \frac{\Sigma x_1 x_2}{N \sigma_1 \sigma_2},$$

and determines the degree of association or correlation between the Gaelic speaking population and the colour class s. Taking as an example s = jet black hair, the following table (Table XXX.) was formed:—

* *British Association Report*, Cambridge, 1904, p. 707.

† *Eleventh Decennial Census of the Population of Scotland with Report*, Vol. I. Table XV. p. xxviii.

TABLE XXX.

Division	Gaelic speaking Population x_1	Jet Black Hair x_2
I. N.	4·82	·30
II. NW.	39·17	·79
III. NE.	− 9·30	−·25
IV. EM.	− 8·35	−·10
V. WM.	1·73	·08
VI. SW.	− 8·57	−·20
VII. SE.	− 9·35	−·38
VIII. S.	−10·15	−·22

An inspection of this table reveals the fact that in *every* division where there is an excess of the Gaelic speaking population there is an excess of the jet black class, and *vice versâ*. The values of the correlation coefficient r and its probable error in the particular case when $r = 0$, or $E_{(r=0)}$, have been evaluated for all the colour classes and the Gaelic speaking population with the following result (Table XXXI.). The ratio $r/E_{(r=0)}$ shows how much the correlation found exceeds the probable error when r is equal to zero.

TABLE XXXI.

Correlation of Hair and Eye Colours with Gaelic speaking population.

Colour Class	r	$\frac{r}{E_{(r=0)}}$
Fair Hair ...	·3482	1·37
Red Hair ...	−·3027	−1·19
Medium Hair ...	−·8663	−3·40
Dark Hair ...	·8126	3·19
Jet Black Hair ...	·9581	3·76
Blue Eyes ...	·8663	3·40
Light Eyes ...	−·1248	−0·49
Medium Eyes ...	−·8760	−3·44
Dark Eyes ...	−·6387	−2·51

This result is of some importance. It shows definitely for the first time the general nature of the colour characters of the Gaelic speaking as against the non-Gaelic speaking population of Scotland. It proves that the proportion of dark-haired and jet black-haired persons is far greater among the Gaelic speaking than among the non-Gaelic speaking population. In technical language, dark hair and jet black hair are positively correlated to the Gaelic speaking population. The association is clear, and the result ought to be of assistance to the student of the Keltic race. The above table also shows that blue eyes are associated with the Gaelic speaking population, the association being slightly

greater than in the case of dark hair, and nearly as great as in the case of jet black hair. The odds against a less correlation than that found are so great as to warrant the conclusion that blue eyes are far more common where Gaelic is spoken than where it is not. Medium eyes are distinctly correlated negatively to the Gaelic speaking population. One may safely conclude that medium eyes are rarer in Gaelic speaking regions than in the rest of the country. Medium hair, and in a lesser degree dark eyes, are also negatively correlated to the Gaelic speaking population, the correlations being appreciable in each case, but fair hair, red hair and light eyes are present in practically the same proportions in both the Gaelic and non-Gaelic speaking populations. Thus, on a direct survey of the Gaelic speaking population, one would expect the group to be much darker in hair colour and more blue eyed persons would be expected among the Gaelic speaking than in the remaining population, the excess being accompanied by lesser proportions of medium hair and medium eyes and also dark eyes. No sensible differences would be expected in the fair-haired, r -haired, and light-eyed classes compared with the general population. The definite relationship between the Gaelic speaking population and certain colour classes now established, enables one to interpret more fully the meaning of the significant differences in the western portion of Scotland. In Table XXX. it is seen that the North-Western, West-Midland and South-Western divisions are the only ones in which there is an excess of Gaelic speaking persons over the general average. In these divisions about 65 per cent. in Sutherland and about 50 per cent. in each of the counties of Ross and Cromarty, Inverness and Argyll speak Gaelic. So far as hair colour is concerned, all these counties show great excess of dark and jet black hair. This excess is therefore due mainly to the Gaelic speaking populations in these counties. Light eyes, although in excess in Argyll, are neither peculiar to the Gaelic speaking population nor to the non-Gaelic speaking population, since the value of the correlation coefficient is a very small one. The one group is likely to have as large a proportion of light eyes as the other. But blue eyes are associated even more intensely with Gaelic speaking people than dark hair, and this class is in excess in Sutherland, Ross and Cromarty, Inverness and the Western Isles. A fairly large proportion of the dark-haired Gaelic speaking people have therefore blue eyes. In these counties, however, fair hair is also in excess, and since the Northern Isles, Orkney and Shetland, are characterised by a large excess of fair hair and blue eyes and by an exceedingly small proportion of Gaelic speaking people, one would infer that blue eyes are largely associated with fair hair in the non-Gaelic portion of the population of these counties as well. Thus these counties consist of a mixture of fair-haired, blue-eyed, or blonde non-Gaelic speaking population (or if Gaelic speaking, at least of non-Keltic origin) and a dark-haired Gaelic speaking population. The distribution of eye colour in this latter population is unknown, but all classes of eyes are most probably represented, a fairly large proportion of blue eyes being quite certain.

IV. *Relationships between Pigmentation, Density of Population, and Foreigners.*

In the Census Report already referred to, the number of persons per square mile is given for each of the eight chief divisions of Scotland*. The means are at hand therefore to compare the density of the population with pigmentation. With regard to the foreign element, one would naturally come to the conclusion without examining the actual data that foreigners are likely to be found in the more densely populated areas of the country. Business leads them to where the industries are and therefore to where closely packed populations reside. It is desirable therefore that any correlation existing between the two should be measured. The association has been measured from two sets of data. The degree of correlation has been determined (1) between foreigners and density (number of persons per square mile), and (2) between foreigners and the number of families (α) living in one and two rooms, (β) living in three to nine rooms, and (γ) living in ten rooms and upwards. The correlation coefficients were calculated from the following table (Table XXXII.):—

TABLE XXXII.

Division	Persons per square mile	Number of families living in (per 1000 of each division)		
		One and two rooms	Three to nine rooms	Ten rooms and upwards
I.	31	535·8	440·4	22·5
II.	23	490·9	468·3	40·6
III.	127	394·3	569·4	36·3
IV.	166	549·8	419·0	31·1
V.	87	552·5	408·6	38·8
VI.	827	686·4	296·2	17·3
VII.	363	530·7	422·1	47·2
VIII.	62	376·9	562·9	60·2

The following table (Table XXXIII.) gives the population, the number of foreigners, and the number per 1000 of the respective populations, of each division in Scotland:—

TABLE XXXIII.

Division	Population	Foreigners	Number of Foreigners per 1000	Deviation from mean per 1000
I.	112175	147	1·3105	−1·6643
II.	166554	124	0·7445	−2·2303
III.	460941	621	1·3472	−1·6276
IV.	665215	1515	2·2775	−0·6973
V.	348585	1044	2·9950	0·0202
VI.	1862775	15062	8·0858	5·1110
VII.	662415	3888	5·8694	2·8946
VIII.	193443	226	1·1683	−1·8065

* *Eleventh Decennial Census.* Appendix Tables, p. xxxv.

The last column in above table has of course to be compared with each of the values for the various classes of hair colour and eye colour and with the density figures. The values of r, the correlation coefficient, and r/E_r are given in the following tables (Tables XXXIV. and XXXV.):

TABLE XXXIV.

Foreigners and Density.

Correlation between	r	$\frac{r}{E_r}$
Foreigners and Density	·9456	37·46
" and Number of families in 2 rooms and less	·7555	7·38
" and Number of families in 3 to 9 rooms	−·7793	−8·32
" and Number of families in 10 rooms and upwards ...	−·3362	−1·77

These results are interesting. They show that foreigners tend (1) to reside in most densely populated areas, (2) to reside in districts where families live in one room or two rooms, and (3) not to reside as a rule in districts where families live in three to nine rooms. There is not a very decided tendency against their residing where families live in large houses with many rooms.

The following are the results of the comparison between foreigners, density and pigmentation:

TABLE XXXV.

Correlations between Density of Population, Foreigners and Pigmentation.

Colour	Density		Foreigners	
	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$
Hair:				
Fair ...	−·805	3·16	−·788	3·09
Red ...	−·001	·005	−·093	·37
Medium ...	·716	2·81	·757	2·97
Dark ...	−·195	·77	−·243	·95
Jet Black ...	−·460	1·81	−·497	1·95
Eyes:				
Blue ...	−·612	2·40	−·668	2·62
Light ...	·090	·35	·219	·86
Medium ...	·560	2·19	·523	2·05
Dark ...	·533	2·09	·514	2·02

The striking feature in the above table is the great similarity in the results in comparing foreigners with pigmentation and density with pigmentation. The results show the futility of attempting to draw any conclusions as to the probable predominant colour classes of foreign immigrants from these tables since the

correlation between foreigners and density is exceedingly high. It is certainly the case that foreigners coming into this country live in districts in Scotland having on an average distinctly greater proportions of medium haired, medium eyed and dark-eyed persons among their number than that found for the general population. But these are just the classes which are in excess in densely populated parts, and foreign immigrants reside for the most part in these denser centres. One cannot therefore say from the foregoing whether the foreign immigrants have large proportions of these classes among their number or not. It is not known what the proportions are. It has simply been proved that they are associated with densely populated centres in Scotland. The colour characters of the immigrants themselves must be investigated. The effect of the foreign element in the population will be considered in detail in the special section on Glasgow and environs.

The subsection can be summarised as follows:

{Foreign / Immigrants} on reaching this country tend to reside in {Densely / Populated / Areas} where (among school children) excesses are found of the following classes, namely: {Medium Hair / Medium Eyes / Dark Eyes}

V. *Relationship between Pigmentation and the Death Rate.* It is stated by Pearson* that there is a positive correlation between fairness and disease in childhood. It has long been known that there is a correlation between density of population and the death rate not due directly or mainly to the crowding of persons together but to the association with density of filth, poverty, drunkenness and the like. Russell has shown the correlation between the size of house and the general death rate†. Newsholme‡ pointed out in 1891 that the true test of density is a statement of the number of persons living in each occupied room. Applying any test of density, the correlation between it and the death rate is high, using Scottish figures. Taking for instance the number of persons per square mile, the correlation

TABLE XXXVI.

Correlation between Density of Population and Death Rate in Scotland.

Division	Deviation from mean number of persons per square mile	Deviation from mean Death Rate
I.	−179·75	−1·240
II.	−187·75	− ·078
III.	− 83·75	−1·012
IV.	− 44·75	·138
V.	−123·75	− ·275
VI.	616·25	2·450
VII.	152·25	·315
VIII.	−148·75	− ·297

* Pearson: *Biometrika*, Vol. III. p. 465.

† Russell: *Proceedings of Glasgow Philosophical Society*, Nov. 1888.

‡ Newsholme: *Journal of Royal Statistical Society*, Feb. 1891.

was found to be $r = \cdot 9125$ from the accompanying table (Table XXXVI.). Diagram XIX. shows graphically the connection between density and other characteristics in the population.

Thus the association is very high. It will be of interest now to note what relationship, if any, exists between colour and the death rate. The following results were obtained (Table XXXVII.).

TABLE XXXVII.

Correlation between Death Rate and Pigmentation.

	r	$\frac{r}{E_{(r=0)}}$
Hair:		
Fair ...	−·806	−3·16
Red ...	−·347	−1·36
Medium ...	·567	2·23
Dark ...	·064	·25
Jet Black ...	−·252	−·99
Eyes:		
Blue ...	−·488	−1·91
Light ...	·226	·89
Medium ...	·284	1·11
Dark ...	·410	1·61

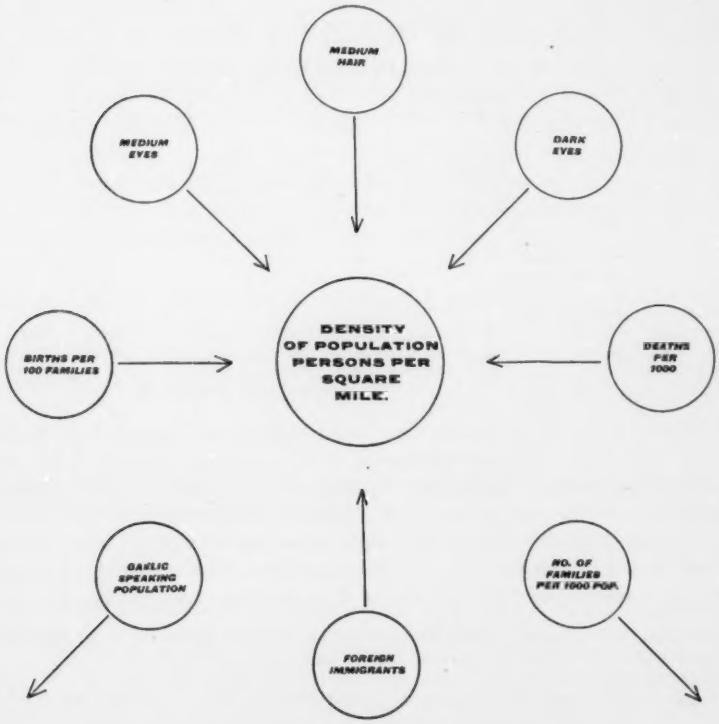
This result, a positive correlation between the death rate and medium hair, and another between death rate and dark eyes, was to be expected, since density is similarly associated with colour. The denser the population is the greater is the death rate; the denser the population is the greater is the excess of medium hair; therefore the greater the excess of medium hair, the greater the death rate. (1) Is it to be concluded that medium haired or dark-eyed people are less virile and cannot stand the strain of city life? (2) Must one say that the blue-eyed fair-haired classes have been all killed out in densely populated areas since they have less resistive power and it is now the turn of the darker section of the population who now presumably show greater mortality? (3) Or must it be said that the conditions of town life are such as to cause a larger section of the fair-haired class to become so much more sensibly darker in towns than in rural districts so as to be classed as medium or brown? There is a darkening in the fair-haired class with age; that much is well known. Is the darkening more intensely operative in towns, and why? (4) If not, can any explanation be offered as to why medium hair colour is associated positively with density and thus with the death rate—why a proportion of medium haired persons much above the average live in more densely populated parts (and are thus of the poorer class) where mortality is higher than the average? An attempt will now be made to answer these questions so far as they can be answered, seriatim.

VI. *The probable Cause of the Association of the Medium or Brown Haired Class with Density of Population.* It cannot be said from the data of this survey

what colour class is more virile than another or whether there is any difference among the classes. Is such an hypothesis necessary? This question is put, because it can be quite easily seen that if there is a large proportion of the medium class living in very densely populated areas, deaths among medium haired persons will be more frequent there than in the rest of the country. But this does not explain why medium haired persons are in excess in densely populated parts. No reason is known why darkening with age should be more intense in densely populated centres, but it is a possible explanation of the excess of medium in these centres and the hypothesis should be proved or disproved by observation. If there was any special force tending to send medium haired and dark-eyed persons in from the country to towns, that would explain the excess. But no such force is known to exist. If foreign immigrants had a high percentage of medium hair this might be a factor, but foreigners coming into this country are, on an average,

DIAGRAM XIX

Relationship between Density and the other characteristics of the Scottish Population



darker-haired* than the Scottish population. With a less proportion of medium hair than that occurring in this country, the foreigners—a handful compared with the total population of towns—could have no effect in this direction. They are likely, from actual observations, to have an effect in *very* densely populated areas in the direction of darkness of hair and dark eyes. If Irishmen and Englishmen were browner-haired on an average than Scotchmen, and if it was proved that a high proportion of them lived in densely populated areas of Scotland, this would be an important factor and a probable explanation. It is true that, at any rate in Glasgow, the Irish are found in large numbers, but from the results of this survey (see Glasgow section—Irish children) and the results given by the pioneer observer of colour in this country, Beddoe†, Irishmen have no greater proportion of the medium class on an average than Scotchmen. Beddoe's statistics for England have also been tabulated and a general percentage evaluated. The English appear on an average to be no browner-haired than the Scot. Both indeed seem likely to have a less proportion of this class. Pearson's statistics for English boys show that they are fairer than Scottish boys. There seems however to be a higher proportion possessing jet black hair.

The following table (Table XXXVIII.) shows the colour distributions of English, Scottish, and Irish populations, as at present known.

TABLE XXXVIII.

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
(1) Irish	10·4	4·6	33·4	40·5	11·0	—	66·5	14·7	18·6
(2) English, North of England	21·3	5·8	41·6	28·6	2·6	—	60·5	14·7	24·7
(3) Scottish Adults, Probable Distribution	11·5	4·2	55·9	28·4	—	—	27·8	45·9	26·3
(4) Scottish Boys, Actual Observation	25·0	5·5	43·3	25·0	1·3	14·7	30·3	32·7	22·3
(5) Irish Boys, Glasgow ...	22·1	5·1	35·1	33·1	4·6	21·2	26·0	28·4	24·4
(6) English Boys	33·5	4·1	34·0	26·5	1·9	—	41·5	37·0	21·6

The figures for the Irish and English populations are derived from Beddoe's tables†. The figures for Scottish adults are the author's, deduced from results from the Aberdeenshire adults and Scottish school children‡. The figures for Scottish boys are from the present data; those for Irish children are also from the present data. Pearson's figures are taken from the Fourth Huxley Lecture§. The table is not intended to represent the *actual* distributions for the three kingdoms, but merely to show that the excess of medium hair found in Scotland is not

* See actual results in section on Glasgow; also Livi and others on Italians, Jews, Russians, etc.

† Beddoe: *Races of Britain*, pp. 188, 189; and pp. 160 et seq.

‡ *Biometrika*, Vol. v. pp. 341, 342.

§ *Journ. Anthrop. Instit.* Vol. xxxiii. 1903, pp. 214, 215.

likely to be from Irish or English sources. The presence of neither foreigners, Irishmen, Englishmen, nor of brown-haired immigrants from rural districts at home (although they might contribute a little) can explain the excess of medium hair. None of these groups are likely to have contributed; it has been proved, in short, that they do not. Having considered among others the effect of the presence of persons of a non-Scottish origin—the effect of a section of the population proved to be present whose origin is forth of Scotland—and shown it to be inappreciable or non-operative, one must conclude that the cause has an internal origin and is not derived from an external source. It must be something operating within the Scottish population itself. What factor is operating within Scotland producing an excess in densely populated areas of the various shades of brown hair classed as medium?

One or more of at least three factors might possibly operate and provide the explanation.

(A) *Darkening among the fair-haired might occur earlier in towns and might be more intense.* No grounds exist for this explanation. It is purely hypothetical and requires investigation. (B) The medium class might be the most fertile. Since this class is correlated with density of population, since the lower classes live in the densely populated areas, and since it has been shown that the lower classes are the most fertile, one might conclude that the medium class is the most fertile of the fertile lower classes. If true, this would explain the excess. (C) The excess might be due to the effect of blending of the fair and dark classes of the population.

With regard to (A) until observations from towns and rural districts, bearing on this, are calculated, the truth or otherwise of the hypothesis cannot be verified. The pigmentation survey returns contain no data capable of furnishing the means of testing this hypothesis.

(B) *The probability of the medium haired class being the most fertile.* Comparing the number of births per 100 families (calculated from the figures of the Census Report—the only data at present available to estimate the relative fertility in the various divisions of Scotland) with density of population, the value of the correlation coefficient was found to be

$$r = \cdot 782 \pm \cdot 093\text{; and } \frac{r}{E_r} \text{ thus} = 8 \cdot 44\text{; and } \frac{r}{E_{(r=0)}} = 3 \cdot 08.$$

That is to say, births per family are greater in number in more densely populated areas than in sparsely populated parts*. Of course this does not give the measure of true fertility. To get this, one would require to get a return of the number of wives for each division, whose ages are within the childbearing range, and compare

* On the other hand on comparing the number of families per 1000 of the population with density of population the correlation was found to be negative ($r = -\cdot 6109 \pm \cdot 1495$). This does not necessarily mean that in towns the families are larger. The large population of young men and women employed in industries and otherwise and drawn from less densely populated areas contribute largely, if not mainly, to the result.

this with the number of births in each division. The value, $r = \cdot 782$, cannot be taken as the true measure unless the ratio of the number of possibly fertile wives to the number of families is quite approximately the same in each division. The correlation, however, between the number of births per family and density of population is so high as to warrant the conclusion that fertility is really greater among the inhabitants of densely populated areas. Since the more densely populated centres are occupied by the lower classes, this is tantamount to saying that the lower classes are more fertile than the remaining section of the population, a conclusion already reached by several observers. Let now the number of births per family, in each division, be compared with the pigmentation data. The following results were obtained:

TABLE XXXIX.

Correlation between Pigmentation and Births per Family.

Colour	r	$\frac{r}{E_{(r=0)}}$
Hair:		
Fair ...	−·936	−3·67
Red ...	−·043	−0·17
Medium ...	·727	2·85
Dark ...	−·059	−0·23
Jet Black ...	−·504	−1·98
Eyes:		
Blue ...	−·775	−3·04
Light ...	·386	1·51
Medium ...	·671	2·63
Dark ...	·292	1·15

These results show that the number of births per family is greater where there are excesses of medium hair and medium eyes and is much less in regions of excess of fair hair and blue eyes. Now these results are similar to those obtained in comparing density of population with pigmentation except that dark eyes are significantly associated with density, but not with the birth rate per family. Thus the lower class population is associated with a higher birth rate per family and with an excess of medium hair and medium eyes over the general population. Is one to say that the medium haired, medium eyed classes are as a whole more fertile over the whole country; or are only those sections of them living in more densely populated parts (i.e. working class sections of these classes) the more fertile? That question cannot be answered from the present data, but it can be said that the medium haired, medium eyed and populous lower classes are more fertile than the remaining population, and this factor is probably operating in favour of producing distinct excess of these classes in the more densely populated areas of Scotland where they are found.

(C) *The probability that excess of medium hair in dense centres is due to blending.* Consider first a population consisting of more or less isolated groups of

fair-haired and dark-haired people living in sparsely populated regions. The chances of conjugal union of persons of the same colour class, if the mating occurs at random or is pangamic, are greater than if they lived all together as one group in a densely populated town. In the past, more unions between persons of the dark-haired class (for instance, in the west coast) were likely, on the assumption that mating occurred purely at random, to occur than between them as a class and the fair-haired class. Similarly, isolated groups of the fair-haired class would have more unions among themselves than with the smaller dark-haired groups. On the other hand, however, wherever towns sprang up, the different classes would be brought more in contact with one another and the chances of union among all classes with one another would be greater. But does mating actually occur purely at random? That is to say, taking the character here considered, hair colour, does the fair-haired class, for instance, select mates indiscriminately from the other classes or do they tend to mate more with members of their own class? Similarly, taking eye colour, what is the nature of the mating? Pearson* has shown that, for certain measurable characters, like tends to mate with like; that is, assortative or homogamic mating exists. For eye colour he has shown that both homogamic and preferential mating exist. Can one say with respect to hair colour whether the mating is homogamic, preferential or pangamic? In the past, with isolated groups and with the clan system in vogue, endogamic mating would certainly exist and be a powerful factor in determining the prevailing colour characters. Thus one would expect at the present day to find a section of the population in the Highlands with characters distinctly different from another section, and this, one finds, is the case. Different race or clan groups have married within the race or clan and retained the ancestral characters. But endogamic mating can now no longer be a powerful factor, except in isolated cases, since greater intermixture and greater dispersal of the population now occur than was ever possible in the past. Retaining this form as possibly contributing, and remembering that mating of unlikes (conjugal union of say a member of the jet black class with a member of the fair-haired class) is also quite possible, the five possible forms emerge, namely:

Homogamic = like with like;
Endogamic = members of the same clan;
Preferential = preference for a certain colour;
Heterogamic = mating of unlikes; and
Pangamic = random.

Now while it has been shown that inheritance of eye colour is more of the exclusive form than of the blended form, is it more likely that hair colour (except perhaps red hair which has been already noticed) is a case of blended rather than of exclusive inheritance? As yet there are no statistics from which the intensity of blending can be directly proved or disproved. One can only advance the theory that blended inheritance prevails largely in hair colour, and see whether it explains the excess of medium hair in densely populated centres. Blended inheritance in

* Pearson and Lee: *Biometrika*, Vol. II. pp. 357—462; and pp. 481—498; and many others.

hair colour certainly exists, although no statistics are forthcoming to prove its intensity. The average observer will have noticed that the offspring of parents, one fair and one dark, are not uniformly fair and dark, but have also on an average among their number members of the brown-haired or medium class. What the proportions of each are, on an average, will be revealed by observation. What form the distribution takes does not affect the argument. Granted that pangamic mating (not excluding other forms) now exists for hair colour among the Scottish people and granted blended inheritance as probably occurring as one of the results, and the phenomenon of regression will appear in hair colour. The colour of future generations of offspring will tend to become brown-haired and in a few generations a brown type will be established breeding true to itself. Thus in densely populated areas where greater opportunities for random mating exist, a greater proportion of medium hair will arise, granting blending of hair colour as an appreciable factor, but not of course debarring exclusive and even particulate inheritance as operative as well. This alone, or together with the suggested greater fertility of the medium haired class, would explain the excess of medium hair found in densely populated areas particularly in and around Glasgow, an excess which is not explainable by the presence of non-Scottish or Scoto-Keltic elements in the population. As has been said before, it cannot be proved from the present data what is the cause of the excess, and the foregoing is only the probable explanation. The proof or otherwise of the validity of the theory will be forthcoming when the results of direct observations on parents and offspring have been made, tabulated and analysed.

VII. *Colour classes which are associated geographically.* (α) *Hair classes which are associated with one another.*—The theory that brown hair is really a blend of fair and dark is supported by the fact that throughout the country excess of the class is not generally associated with excess of other hair colour classes. In order to determine the extent of the association of excesses and otherwise of the various colour classes, the percentages of all the classes were compared with one another and the correlation coefficients determined. The following table (Table XL.) gives the numerical values of the correlations of each class with all the other classes. One must be careful as to the meaning of the result. Association of excesses of fair hair and blue eyes (a positive correlation) does not necessarily mean from this portion of the analysis that the blonde type predominates in the region of excess. All the analysis tells one is that regions of excess of fair hair are also regions of excess of blue eyes. This will be evident when one considers the other associations with fair hair. Examining the table it will be seen that regions of excess of jet black hair are also generally regions of excess of *fair* and *dark*. This combination could not obviously occur in the same person. Regions of excesses of fair and dark indicate the presence of two types—a heterogeneous and not a homogeneous population. On the other hand, examine the column indicating the associations with excess of medium hair. *Excess of medium hair as a rule is associated with excess of no other colour class.* The negative correlations

show that regions of excess of medium hair are *not* regions of excess but of defect of dark and jet black hair. This would seem to indicate a greater approach towards fusion of the fair and dark types in more densely populated centres and the consequent gradual disappearance of these types to form the medium (brown or dark brown) type. There is no bias for or against the presence of red as a class with excess of medium hair. *Excess of red hair is found as a rule only in regions where the proportion of the dark-haired class is well below the average.* A slight excess of fair is associated with excess of red. The probable reasons for these positive and negative associations will not be further entered into here. Sufficient evidence has not yet been accumulated to explain the differences with regard to pigment and matrix in human hair*. The present grouping of the shades into five classes is based on the general appearance of hair in the mass. The problem generally is one on inheritance, but the material to solve the problem comes from divers sources, chemical, microscopical, biological, statistical. Until this material is collected and dealt with, no explanation of any great weight from a scientific point of view can be given, particularly as to the shades of red hair, although several quite plausible theories can quite easily be advanced. One must therefore be content to state the bare facts as they emerge from the statistical analysis. It does not appear to be an insoluble although perhaps it is a somewhat difficult problem. When more light is obtained the explanation will be forthcoming.

(β) *Eye classes associated with one another.—Excess of dark eyes in densely populated centres.* The only class which is not positively associated significantly with any other class is the class of light eyes. Excess of light is negatively associated with blue and dark. Where light eyes are in excess, blue and dark eyes are not likely to be so, but the reverse; there is likely to be a defect of these classes. Excess or defect of light eyes is not connected with any excess or defect of medium eyes. Excess of blue eyes is as a rule associated with defects in the frequencies of the other classes of eye colour. Excess of dark eyes accompanies excess of medium and defect of the other two, light and blue. So that, broadly speaking, it is found that excess of blue eyes is found alone, excess of light eyes is found alone and excesses of dark eyes and medium eyes occur together. This is an interesting result, since it has been shown by both Galton and Pearson that exclusive inheritance prevails in the dark-eyed class. That is to say, the offspring for example of parents one dark-eyed and the other light-eyed or blue-eyed are, as a rule, either dark-eyed or light-eyed or blue-eyed. Medium eyes do not usually appear from such unions. There is no evidence as yet as to the blending or otherwise of the three classes, blue, light and medium. But since the offspring of parents, one dark-eyed and the other medium eyed, are likely to be either dark-eyed or medium eyed, unions among the two classes for generations would have no appreciable effect on the eye colour of the offspring, and therefore, as the results of

* The chemical and microscopical aspects of the problem of hair colour will be dealt with by the author in another memoir.

this investigation show, one would still have the two classes, just as though there had been no intermarriages in these classes at all. Pearson* has shown that preferential mating is likely to be operative against the dark-eyed class and he also shows from Galton's data that they are more fertile under their present environment than say the light-eyed. The results of the present analysis do not tend to confirm this (see Table XXXIX.), but it must be remembered that the comparison was not made between births with respect to possibly fertile wives and pigmentation, but between births per family and pigmentation. Thus, with

TABLE XL.

Association of Colour Classes in the same Regions.

Values of r the correlation coefficient.

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Fair ...	1	·3074	−·6916	−·0867	·3733	·7207	−·3044	−·5786	−·4233
Red ...	—	1	·0873	−·5881	−·3414	·0324	−·3966	·3858	·0022
Medium ...	—	—	1	−·6459	−·9039	−·9431	·2273	·8563	·6874
Dark ...	—	—	—	1	·8443	·5075	·1166	−·6295	−·5110
Jet Black ...	—	—	—	—	1	·8728	−·2565	−·8211	−·5200
Blue ...	—	—	—	—	—	1	−·4329	−·8226	−·5429
Light ...	—	—	—	—	—	—	1	−·0905	−·4290
Medium ...	—	—	—	—	—	—	—	1	·6991
Dark ...	—	—	—	—	—	—	—	—	1

TABLE XLI.

Classes, excesses of which are found together in the same regions.

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Hair:									
Fair ...	—	+	—	—	+	+	—	—	—
Red ...	+	—	—	—	—	—	—	+	—
Medium ...	—	—	—	—	—	—	—	+	+
Dark ...	—	—	—	—	+	+	—	—	—
Jet Black ...	+	—	—	+	—	+	—	—	—
Eyes:									
Blue ...	+	—	—	+	+	—	—	—	—
Light ...	—	—	—	—	—	—	—	—	—
Medium ...	—	+	+	—	—	—	—	—	+
Dark ...	—	—	+	—	—	—	—	+	—

The rows or columns show for any one class what other classes are associated with it.

* Pearson: *Phil. Trans.* Vol. 195, pp. 79—150; and *Grammar of Science*, 1900; page 428.

the proper data, it is possible that the *positive* association may become a *significantly positive* one. Since excess of dark eyes in the Scottish population has been here shown to occur in densely populated parts, the dark-eyed class here at any rate belongs largely to the poorer section of the population. But the lower classes are more fertile than the upper classes. If the dark-eyed portion of the lower classes is more fertile than the remaining portion, and if a selective death rate does not operate against the dark-eyed, this would go far to explain the excess of dark eyes in densely populated parts not explainable by the presence of foreigners or of migrants from contiguous rural areas.

VIII. *Relationships between Pigmentation and Physical and Mental Defects.* In a recent memoir*, already referred to, it was shown, using the division analysis results of the present data, that cases of insanity were in excess of the mean in areas where there was an excess of light eyes in the population. The enquiry has been extended in order to note whether excess of any particular hair colour or eye colour is associated with physical or mental defects such as blindness, deafness and imbecility. The following results were obtained, the results for insanity cases being included. The figures used in comparing the results were taken from the Census Report 1901.

TABLE XLII.

Relationships between Pigmentation and certain Defects or Affections.

Hair Colour.

Defect or Affection	Fair		Red		Medium		Dark		Jet Black	
	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$
Insanity ...	−·024	− ·10	−·582	−2·28	−·128	− ·50	·340	1·33	·084	·33
Imbecility or Feeble-mindedness ...	·608	2·38	−·213	− ·83	−·942	−3·69	·672	2·63	·893	3·50
Blindness ...	·565	2·22	·006	·02	−·868	−3·40	·546	2·14	·885	3·47
Deafness ...	·300	1·18	·054	·21	−·707	−2·77	·572	2·24	·789	3·10
Deaf and Dumb ...	·126	·49	·148	·58	−·136	− ·53	−·026	− ·10	·273	1·07

Eye Colour.

Defect or Affection	Blue		Light		Medium		Dark	
	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$	r	$\frac{r}{E_{(r=0)}}$
Insanity ...	−·072	− ·28	·695	2·73	−·322	−1·26	−·482	−1·89
Imbecility or Feeble-mindedness ...	·841	3·30	−·253	− ·99	−·753	−2·96	−·547	−2·15
Blindness ...	·951	3·73	−·464	−1·82	−·775	−3·04	−·442	−1·73
Deafness ...	·819	3·21	−·386	−1·51	−·609	−2·39	−·489	−1·92
Deaf and Dumb ...	·309	1·21	−·453	−1·78	−·118	− ·46	·149	·58

* *Biometrika*, Vol. v. p. 342.

These results show that the distribution of cases of mental affection differs from those of the three other classes of defects. Excesses in the number of cases of imbecility, blindness and deafness occur in regions of excess of blue eyes and dark and jet black hair. From the results of the enquiry into the relationship between the Gaelic speaking portion of the population and pigmentation, it was shown that these were the classes correlated positively with excess of Gaelic speaking people. The correlation between this portion of the population and the four groups were accordingly calculated when it was found to confirm the conclusion that the Gaelic portion was correlated positively to those groups as expected, as the following table (Table XLIII.) shows:

TABLE XLIII.

Relationship between the Gaelic speaking Population and Defects.

Defect or Affection	Value of r	$\frac{r}{E_{(r=0)}}$
Deaf ...	·865	3·39
Blind ...	·884	3·47
Imbeciles ...	·788	3·09
Deaf and Dumb ...	·295	1·16

From whatever cause, therefore, a significantly greater number of cases of imbecility, blindness and deafness occur in Gaelic speaking regions than occur throughout the country in general. Emigration of the fitter portion of the inhabitants from the west in greater proportion than from other parts of Scotland would explain the occurrence of larger proportions of cases of defect in the Highlands. It must not be concluded therefore that Gaelic speaking Scots on an average are in any way inferior physically to Lowland Scots—perhaps the reverse is the case—or that a really higher proportion of defects exist among the race or races which speak the Gaelic language.

(10) *Degree of resemblance between the Boy and Girl Populations in each of the Colour Classes.*

It has been seen in a general way that the boy and girl populations agree in many localities in showing excess or defect frequencies in the various classes compared with the general population, and in several cases it was found that the populations differed, excesses in one sex being associated with defects in the other and *vice versa*. It is necessary therefore that the difference between the two populations generally should be measured. It will be seen then which of the classes shows the greatest agreement and which the greatest difference, or whether there is any appreciable difference in the extent of association or independence of the two sexes as separate populations.

(α) The degree of resemblance between the boy and girl populations in the same localities was determined, using in the first instance the percentage figures as

found for the eight great divisions of Scotland. If x_m = deviation from the mean percentage of any class in any division for boys, x_f = the corresponding deviation from the percentage in the same division for girls, σ_m and σ_f the standard deviations of the respective percentage distributions,

$$r = \frac{\Sigma x_m x_f}{N \sigma_m \sigma_f}$$

and measures the general degree of resemblance between the boy and girl populations in the same division.

(β) In the second instance the values of the relative local differences found for counties and cities were used. If l_m = the relative local difference of any class for boys, and l_f = the corresponding relative local difference of the same class in the same locality for girls, then

$$r = \frac{\Sigma l_m l_f}{N \sigma_{l_m} \sigma_{l_f}}$$

and is a measure of the general resemblance between the boy and girl populations on the county and city basis of grouping.

(γ) In the third instance the counties alone were used, the cities being included in their respective counties while percentages were used as the basis, just as in the case of the great divisions. The following results were obtained:

TABLE XLIV.

Degree of Resemblance between the Boy and Girl Populations.

Colour	Values of r percentages Divisions	Values of r Counties and Cities—*RLD.*	Values of r Percentages Counties
Hair:			
Fair ...	·83	·83	·63
Red ...	·73	·68	·49
Medium ...	·93	·87	·74
Dark ...	·72	·68	·72
Black ...	·89	·71	·73
Average ...	·82	·75	·66
Eyes:			
Blue ...	·99	·95	·92
Light ...	·92	·86	·82
Medium ...	·85	·83	·79
Dark ...	·91	·91	·91
Average ...	·92	·89	·86

These results show that on an average any excess or defect in the boy population from the general mean in any locality is accompanied in about 70 to 90 per cent. of the cases by a corresponding excess or defect in the girl population and *vice versa*. The agreement is least in the case of red hair.

It may be of interest to point out that Tschepourkowsky has determined the mean resemblance between man and woman to be about ·8, the characters studied interracially being stature, relative arm length, cephalic index and four other measurable characters*.

(11) *The Colour Characteristics of the Population of Greater Glasgow and Environs.*

I. *Introductory.—Tables of classified data.* The city of Glasgow deserves special investigation for many reasons. (1) By far the largest in Scotland, the second city of the Empire contains one-fifth of the total population of the country. (2) Glasgow and the immediately adjacent counties, that is, Lanark, Renfrew, Ayr, Dumbarton and Stirling, contain one-half of the whole Scottish population. (3) Not only are these counties the most densely populated ones, but Glasgow itself greatly exceeds any Scottish town in the density of its population. (See Table LIII.) (4) The Census shows it to contain a much larger proportion of foreigners than any other town in Scotland. The Gaelic speaking population owing to its proximity to the Highlands is well represented. Ireland is also well represented. (5) Finally, it has been shown from the results of the present analysis that the great western city diverges in an extreme degree from the rest of Scotland not only in the distribution of hair colour of its school population but also in the distribution of eye colour, both for boys and girls.

The following table (Table XLV.) shows the observed and expected results for Glasgow and Govan and Glasgow proper, the expected results meaning of course those which would occur on an even distribution with respect to colour of the whole of the school children throughout Scotland.

TABLE XLV.

Glasgow and Govan.

Result	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Observed ...	17809	4179	36528	21809	965	9941	24661	27021	19667
Expected ...	21267	4308	34240	20478	997	11986	24644	26325	18335
The observed result compared with the expected one is ...	3458 less	129 less	2288 greater	1331 greater	32 less	2045 less	17 greater	696 greater	1332 greater

* *Biometrika*, Vol. IV. pp. 161—168.

TABLE XLV.—(*continued*).

Glasgow Proper.

Result	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Observed ...	12734	2984	25967	16042	716	6736	17634	19802	14271
Expected ...	15290	3094	24606	14734	719	8628	17714	18934	13167
The observed result compared with the expected one is ...	2556 less	110 less	1361 greater	1308 greater	3 less	1892 less	80 less	868 greater	1104 greater

From the foregoing table it is seen that there are about 3500 less than the expected number of fair-haired children, about 2300 more medium haired and over 1300 more dark-haired. There are 2000 less blue-eyed children than expected, about 700 more medium eyed and over 1300 more dark-eyed children. Such differences, even with the large numbers dealt with in Glasgow, have a definite significance and are not differences which would occur in making a random draw of the same numbers from the general population.

In the county and district analyses, Glasgow has been treated as a unit. The city has been contrasted as a whole with the neighbouring counties and also with the immediately surrounding population, a population which has been divided up into districts. In both cases, it has been shown to be unlike those outside populations. It seems highly desirable therefore to examine Glasgow from the inside in order to see what is the cause of the great difference; whether, analysed intra-locally, the population of the city is different in different parts of the city; and whether these various divisions agree with or differ from the surrounding suburban areas.

Under the School Board of Glasgow the city is divided into ten educational districts. The accompanying table (Table XLVI.) gives a list of the districts and their respective schools:

In order to have approximately equal numbers in the various areas dealt with by the author, Calton, Camlachie and Bridgeton were grouped into one pigmentation district; Tradeston, Gorbals and Hutchesontown, three other educational districts, were grouped into another pigmentation district. The following pigmentation districts were also constituted for the environs of Glasgow: North Suburban, South Suburban, East Suburban and West Suburban. The following table (Table XLVII.) shows how the pigmentation groups of Greater Glasgow were made up, while the succeeding table (Table XLVIII.) shows the actual frequencies of the various classes for these districts. The results of the analysis of these figures

TABLE XLVI.

Educational District. Name of School.

I. Anderston District.

1. Bishop Street.
2. Finnieston.
3. Overnewton.
4. Anderston.
5. Kelvinhaugh.
6. Kent Road.
*7. Glasgow High School.
8. Washington Street.

II. Milton District.

1. Dobbie's Loan.
2. Henderson Street.
3. Rockvilla.
4. Milton.
5. Garnetbank.
*6. Glasgow High School for Girls.
7. Kay.
8. Oakbank.
9. Grove Street.
10. Woodside.
11. St George's Road.
12. Springbank.
13. Napiershall.
*14. Pupil Teachers' Institute.
15. Dunard Street.
16. Willowbank.
*17. Woodlands Institute School (for Cripple Children).

III. St Rollox District.

1. Kennedy Street.
2. Springburn.
3. Keppochhill.
4. Freeland.
5. Martyrs'.
6. St David's.
7. Townhead.
8. Elmvale.
9. Provanside.
*10. Hydepark.

IV. Dennistoun District.

1. Wellpark.
2. St Rollox.
3. Dovehill.
4. Dennistoun.
*5. Whitehill.
6. Alexander's.
7. Petershill.
8. Rosemount.

Educational District. Name of School.

9. Alexandra Parade.
*10. Golfhill.
*11. Haghill.

V. Calton District.

*1. Tureen Street.
2. St James's.
3. Calton.

VI. Camlachie District.

1. Thomson Street.
2. Barrowfield.
*3. Parkhead.
4. Camlachie.
5. Campbellfield.
6. Annfield.
*7. Newlands.
*8. Quarrybrae.

VII. Bridgeton District.

1. Rumford Street.
2. Hozier Street.
*3. John Street.
4. Springfield.
5. Dalmarnock.
6. Queen Mary Street.
*7. Strathclyde.
8. Special School for Cripple Children.

VIII. Tradeston District.

*1. Centre Street.
2. Crookston Street.
3. Shields Road.
4. Sir John N. Cuthbertson.
*5. Scotland Street.

IX. Gorbals District.

1. Greenside Street.
2. Abbotsford.
3. Gorbals.

X. Hutchesontown District.

1. Rose Street.
2. Camden Street.
3. Oatlands.
*4. Mathieson Street.
5. Wolseley Street.
6. Adelphi Terrace.
*7. Hayfield.

* No returns were received from these schools.

are given in Tables XLIX. and L. (Table XLIX. Relative Local Differences and Table L. General Divergency). The results are also shown diagrammatically in Maps LV. to LXXVIII.

TABLE XLVII.

Name of Pigmentation Groups		Pigmentation Group embraces
I	Anderston	The Wards of Anderston, Broomielaw, Sandyford, Exchange, Blythswood, part of Park
II.	Milton	The Wards of Cowcaddens, Park (part of), Woodside (part of)
III.	St Rollox	The Wards of Townhead, Cowlairs (part of), Springburn (part of)
IV.	Dennistoun	Dennistoun Ward
V.	Calton, Camlachie and Bridgeton ...	The Wards of Calton, Whitevale, Milend, and Dalmarnock
VI.	Tradeston, Gorbals & Hutchesontown	The Wards of Kingston, Gorbals and Hutchesontown
VII.	South Govan	All the Govan School Board area south of the river
VIII.	Partick	Partick; Kelvinside Ward
IX.	South Suburban District	The Parishes of Eastwood, Cathcart, Rutherglen and Cambuslang
X.	North Suburban District	The Parishes of Cadder, New Kilpatrick, Old Kilpatrick and Baldernock
XI.	East Suburban District	The Parishes of Bothwell, Barony and Old Monkland
XII.	West Suburban District	The Parishes of Renfrew and Abbey (Paisley Burgh and Paisley landward)

II. *Analysis of Glasgow Data.* (α) *General Divergency in Colour.* (1) *Degree of General Resemblance of the various divisions of Glasgow to the General Population in Hair Colour.* It will be remembered that in the district analysis, the 13th district, Glasgow and Govan, exhibited the excessive divergencies from the general population as represented by log $P = \overline{44}{\cdot}8$ for boys and log $P = \overline{146}{\cdot}6$ for girls. In the county analysis the chief cities were treated separately from the counties and Govan was separated from Glasgow, when it was found that the values of log P fell—that is, less divergency was exhibited for Glasgow and Govan separately than for Glasgow and Govan together. Still the significance of the divergency was very great. Log P (boys) for Glasgow proper was $\overline{29}{\cdot}5$ and for Govan $\overline{16}{\cdot}9$. For girls the values were $\overline{120}{\cdot}0$ and $\overline{34}{\cdot}5$. Glasgow proper is thus much more divergent than Govan.

From the analysis of Greater Glasgow and environs, one is able to locate the areas of greatest divergency. Of all the pigmentation groups, the sixth group (Tradeston, Gorbals and Hutchesontown) stands out the most divergent in hair colour for both boys and girls. South Govan and Anderston follow a long way behind. From the fact that there is a large excess of medium and dark hair in the girl population, Calton, Camlachie and Bridgeton as a group is as greatly divergent as South Govan, but the boy population is quite a good sample of the

TABLE XLVIII.

Frequencies of the Colour Classes in the various Divisions of Glasgow.

BOYS.

	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Anderston	717	199	1654	960	34	414	1197	1073	880	3564
Milton	1161	322	2411	1322	51	626	1634	1739	1268	5267
St Rollox	741	160	1378	710	15	313	955	1028	708	3004
Dennistoun	825	196	1552	870	34	402	1082	1166	827	3477
Bridgeton Group	1320	286	2518	1448	61	605	1597	2088	1343	5633
Tradeston Group	1122	282	2842	1749	107	527	1829	2136	1610	6102
Partick	932	224	1947	986	49	723	1234	1251	930	4138
Govan South	1054	266	2408	1304	67	628	1554	1669	1248	5099
South Suburban Area ...	970	247	1936	1170	34	634	1283	1425	1015	4357
East Suburban Area ...	1373	293	2681	1493	68	732	1745	2178	1253	5908
North Suburban Area ...	981	267	2082	1121	39	505	1406	1566	1013	4490
West Suburban Area (Paisley)	864	182	1477	787	75	496	983	1123	783	3385
Totals	12060	2924	24886	13920	634	6605	16499	18442	12878	54424

GIRLS.

	Hair					Eyes				Totals
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark	
Anderston	681	172	1479	1005	43	470	979	1092	839	3380
Milton	1149	283	2168	1482	58	654	1633	1599	1254	5140
St Rollox	836	163	1601	1007	46	421	1103	1235	894	3653
Dennistoun	729	143	1422	834	43	384	924	1141	722	3171
Bridgeton Group	1242	289	2586	1643	50	630	1679	2117	1384	5810
Tradeston Group	1190	272	2807	1873	88	640	1865	2134	1591	6230
Partick	870	205	1721	1025	48	708	1159	1107	895	3869
Govan South	1051	249	2344	1321	51	545	1593	1640	1238	5016
South Suburban Area ...	1000	189	1821	1106	32	528	1309	1362	949	4148
East Suburban Area	1448	306	2294	1369	52	673	1577	1963	1256	5469
North Suburban Area ...	1080	220	1825	1095	29	532	1389	1364	964	4249
West Suburban Area (Paisley)	811	173	1389	857	76	497	949	1031	829	3306
Totals	12087	2664	23457	14617	616	6682	16159	17785	12815	53441

TABLE XLIX.

Relative Local Differences. Greater Glasgow and Environs.

BOYS.

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Anderston	− 6·71	·25	3·80	2·65	−1·60	− 5·17	4·29	−3·35	3·44
Milton	− 4·93	2·01	3·69	·12	−1·86	− 5·75	1·14	·46	3·11
St Rollox	− ·36	− ·40	2·88	−1·78	−3·73	− 6·61	1·78	1·76	1·67
Dennistoun	− 1·68	·38	1·63	− ·01	−1·45	− 5·20	1·05	1·03	2·10
Bridgeton Group ...	− 2·66	−1·38	2·18	1·18	−1·14	− 8·41	−3·24	7·03	2·79
Tradeston Group ...	−11·99	−3·01	5·26	6·63	3·58	−13·46	− ·58	3·85	7·74
Partick	− 3·64	− ·22	4·94	−1·80	− ·39	5·16	− ·69	−3·44	·26
South Govan ...	− 7·13	− ·87	5·74	·91	·42	− 4·78	·26	·02	3·75
South Suburban Area	− 4·13	·52	1·55	2·80	−2·81	− ·21	−1·25	− ·02	1·58
East Suburban Area	− 3·07	−1·81	3·30	·43	− ·69	− 4·99	1·31	6·87	−2·06
North Suburban Area	− 4·84	1·36	4·22	− ·10	−2·32	− 6·52	1·48	3·11	·41
West Suburban Area	·78	− ·29	·42	−2·41	−5·09	− ·01	−1·62	·57	1·16

GIRLS.

	Hair					Eyes			
	Fair	Red	Medium	Dark	Jet Black	Blue	Light	Medium	Dark
Anderston	− 9·55	− ·00	3·44	5·83	·33	− 1·59	−1·71	·31	2·88
Milton	− 8·24	1·37	1·93	5·72	− ·54	− 4·37	2·30	−1·48	2·83
St Rollox	− 6·20	−1·74	3·66	3·03	·27	− 5·73	− ·15	2·28	2·49
Dennistoun	− 5·64	−1·50	4·58	1·17	·76	− 4·40	−1·44	4·76	·01
Bridgeton Group ...	−10·47	− ·41	5·71	5·11	−2·47	− 8·73	−2·38	7·23	1·95
Tradeston Group ...	−14·93	−2·63	6·81	8·57	1·48	−10·33	− ·65	3·76	5·30
Partick	− 6·95	·60	4·61	1·57	·18	6·04	− ·48	−4·63	·56
South Govan ...	−10·39	− ·41	8·53	1·54	−1·26	− 8·05	2·26	·97	3·28
South Suburban Area	− 4·84	−1·58	4·01	1·89	−2·61	− 3·91	1·76	1·08	·18
East Suburban Area	− 1·60	1·72	1·64	− ·63	−1·77	− 5·39	−2·40	6·14	·37
North Suburban Area	− 2·97	·26	2·78	·56	−3·17	− 4·34	3·41	·06	− ·11
West Suburban Area	− 3·76	·38	1·35	·70	5·77	·27	−2·02	−1·08	3·20

TABLE L.

Divergency in Hair Colour and Eye Colour. Greater Glasgow and Environs.

	Hair				Eyes			
	Boys		Girls		Boys		Girls	
	Log *P*	*Q*	Log *P*	*Q*	Log *P*	*Q*	Log *P*	*Q*
Anderston ...	$\bar{1}0{\cdot}7$	·0139	$\bar{2}0{\cdot}6$	·0201	$\bar{1}1{\cdot}5$	·0143	$\bar{2}{\cdot}2$	·0066
Milton	$\bar{6}{\cdot}2$	·0114	$\bar{1}5{\cdot}0$	·0179	$\bar{8}{\cdot}9$	·0119	$\bar{6}{\cdot}8$	·0106
St Rollox	$\bar{4}{\cdot}5$	·0090	$\bar{9}{\cdot}6$	·0137	$\bar{9}{\cdot}3$	·0130	$\bar{8}{\cdot}9$	·0122
Dennistoun	$\bar{1}{\cdot}3$	·0150	$\bar{8}{\cdot}9$	·0127	$\bar{6}{\cdot}7$	·0104	$\bar{7}{\cdot}5$	·0117
Bridgeton	$\bar{2}{\cdot}3$	·0069	$\bar{2}\bar{5}{\cdot}4$	·0226	$\bar{2}\bar{2}{\cdot}2$	·0204	$\bar{2}\bar{2}{\cdot}2$	·0210
Tradeston	$36{\cdot}3$	·0263	$\bar{5}\bar{2}{\cdot}6$	·0321	$\bar{4}\bar{4}{\cdot}2$	·0286	$\bar{2}\bar{5}{\cdot}0$	·0224
Partick	$\bar{5}{\cdot}5$	·0101	$\bar{1}0{\cdot}8$	·0143	$\bar{6}{\cdot}0$	·0110	$\bar{1}0{\cdot}9$	·0137
Govan	$\bar{1}1{\cdot}0$	·0150	$\bar{2}\bar{5}{\cdot}2$	·0226	$\bar{6}{\cdot}2$	·0109	$\bar{1}4{\cdot}4$	·0166
South Suburban Area ...	$\bar{5}{\cdot}2$	·0105	$\bar{7}{\cdot}1$	·0125	$\bar{1}{\cdot}6$	·0034	$\bar{3}{\cdot}1$	·0081
East Suburban Area ...	$\bar{3}{\cdot}4$	·0081	$\bar{2}{\cdot}7$	·0063	$\bar{1}2{\cdot}6$	·0149	$\bar{1}1{\cdot}2$	·0149
North Suburban Area ...	$\bar{7}{\cdot}8$	·0116	$\bar{4}{\cdot}5$	·0093	$\bar{9}{\cdot}2$	·0131	$\bar{5}{\cdot}5$	·0099
West Suburban Area ...	$\bar{6}{\cdot}7$	·0109	$\bar{9}{\cdot}8$	·0135	$\bar{1}{\cdot}6$	·0035	$\bar{4}{\cdot}0$	·0069

general population—there is no great excess or defect in any of the classes. Milton, the north suburbs and west suburbs are about equally divergent for boys, and show a fall as compared with those just mentioned. Then follow Partick, St Rollox and the south suburbs. These show a distinct approach to uniformity of distribution and resemble the general population. Finally the boy populations of the adjacent areas of Calton, Camlachie, Bridgeton, Dennistoun and the east suburbs are fair samples of the general population. Of all the pigmentation groups, only the population of the east suburbs among the girls show resemblance to the general population. As indicated by the boy results, the east end of Glasgow is thus the least divergent and the adjacent southern area—Tradeston, etc.—the most divergent.

(2) *Eye Colour.* On examining the results for eye colour, it is seen that Tradeston, Gorbals and Hutchesontown again come out most divergent. Clearly there are elements in this population of a different character from the population in general. Calton, Camlachie and Bridgeton are also very divergent. South Govan follows in the decreasing scale, then Anderston and the other groups. The south and west suburban areas are quite like the general population, but the east suburban group, partaking of the character of the east end of the city, is as divergent as Anderston, a populous centre.

Thus the special features of the divergency analysis of the component parts of Greater Glasgow are that (1) the eastern portion of the city is quite like the general population in hair colour but is most unlike in eye colour; (2) the suburban areas are much liker the general population than the purely city areas;

(3) in several cases the divergencies for the boy and girl populations are unequal. When this is the case, the girl population has the greater divergency.

(β) *Individual Classes.* (1) *Hair Colour.* The relative local differences have in all cases been calculated and show definitely the cause of the divergencies in each pigmentation group. It will be recalled that fair hair is in defect in the city generally. The difference between the city and the general population is very great, 12 and 24 times the standard deviation of sampling of the differences for boys and girls respectively. There is a distinct fall in the magnitude of the difference in taking Glasgow to pieces. Still in no case is fair hair in excess in the city. There is only a slight excess in the west suburban group. Tradeston is prominent in the magnitude of its negative difference, and resembles the figure for Glasgow generally. South Govan and Anderston, also in the heart of the city, follow with large differences. Milton and the three suburbs, north, south, and east, differ in a moderate degree, while St Rollox, Dennistoun and Bridgeton for boys are passable as samples of the general population, such negative differences as they show being quite possible in a draw from an evenly distributed population. In the girl population, however, only the four suburbs are passable as representative of the general population. All the city groups differ widely from the general average. In a word, one or two of the northern areas in Glasgow possess the average proportion of fair hair and are thus somewhat like the suburbs, but the densely populated areas in the city generally are awanting in the proper proportion of the fair-haired class.

There are slight excesses of red hair in Milton, Partick and the north, east, and south suburban groups, but in none of the cases are the excesses significant. Thus the uniformity of the distribution of this colour class is shown to exist practically all over the country, the north-east of Scotland being the exception. No grouping occurs to speak of in the densely populated city of Glasgow and no defect in the frequency of this class occurs to an extent in the least significant. Town and country are thus much alike with regard to this class.

Medium or brown hair however occurs in quite excessive frequencies in several of the city groups, but is less frequent in the suburbs generally. In the west suburban area, Paisley and Renfrew, the proportion is quite an average one. Tradeston, Gorbals and Hutchesontown (♂ and ♀); Calton, Camlachie and Bridgeton (♀); and South Govan (♂ and ♀) are the areas of greatest excess of the various shades of brown constituting the medium class. Dennistoun (♂) and Milton (♀) are fair samples of the general population in this class. In the dark-haired class, Tradeston, Gorbals and Hutchesontown again stand out. The greatest excess of this class is found over the area of these three divisions. Anderston and the south suburban group for boys show perhaps significant excess, but the differences in the other groups although positive are not significant. In the suburbs generally there are less dark-haired children proportionally than in the heart of the city, and the northern portion of the city itself has a less proportion than the southern and eastern portion. With regard to the small class of jet black haired persons,

Tradeston, Gorbals and Hutchesontown are the only divisions of the city which show significant excess. Excess occurs outside the city only in one suburban group, that of the west, Paisley and Renfrew.

(2) *Eye Colour.* The blue-eyed class, much below the average for Glasgow as a whole, shows significant negative differences in all the divisions and groups excepting the Partick and Kelvinside group, which shows a decided excess. Light eyes are in excess only in Anderston, the heart of the city, and in the north suburban area. There is a slight excess among girls in the South Govan group. Medium eyes are in excess in the east of Glasgow and in defect in the west. Starting in the north suburban area, the excess appears in St Rollox, Dennistoun and the Bridgeton group and finally in the Tradeston group. Govan, the south and west suburbs are like the general population. The defect is greater in Partick. The distribution of dark eyes is interesting on account of the fact that excess in Scotland generally is limited, when a large number of cases is considered, to one region of Scotland, that of Perthshire and Forfarshire. The only suburban area showing excess of this class is the west (Paisley and Renfrew) for girls. There is a slight excess in the boy population of the south suburban area. In the city, Partick is different from the rest of the population in that it possesses the average number—it is quite like the general population for this class. All the other divisions and groups show excess of dark eyes. It is most marked in the Tradeston group, the excess there being highly significant. South Govan follows and then Anderston and Milton. The excess is significant for boys in the Bridgeton group but not quite significant among the girls of that group.

(γ) *General view.* The predominant colours of each of the divisions of Glasgow can now be stated. They are given in the following two tables. Table LI. shows significant positive differences only and these are classed so as to show the intensity of the excesses. Table LII. is a condensation of Table LI. and gives a brief specification of each division.

Taking a general survey of the pigmentation distribution of Greater Glasgow as shown by an analysis of its divisions and the environs, one sees that the excesses of medium and dark hair and medium and dark eyes (found in considering Glasgow as a unit) are not evenly distributed over the city and suburbs. *It is however the predominant feature of the more densely populated and larger portion of the city to be brown or dark in hair colour and medium or dark in eye colour. This of course but confirms the general result in comparing density with pigmentation.* There are some interesting features in the colour distribution which deserve special mention. The occurrence in certain parts of Glasgow of excesses of classes generally deficient in the city (either with or without the prevailing colours) is striking. Why, for instance, should Anderston have an excess of light eyes in the boy population? Why should Milton be the only district having even a slight excess of red hair? Why should the Tradeston group be the only one in the city having an excess of the jet black class, and be otherwise so very divergent as it has proved to be? Why should Partick be the only division in Glasgow having blue eyes in excess,

TABLE LI.

Specification of the Greater Glasgow Population.

(Only significant positive relative local differences shown.)

BOYS.

	Anderston	Milton	St Rollox	Dennistoun	Bridgeton Group	Tradeston Group	Partick	South Govan	S. S.	E. S.	N. S.	W.S.
Fair ...	—	—	—	—	—	—	—	—	—	—	—	—
Red ...	—	2	—	—	—	—	—	—	—	—	—	—
Medium ...	4	4	3	—	—	5	5	6	—	—	4	—
Dark ...	3	—	—	—	—	6	—	—	3	—	—	—
Jet Black ...	—	—	—	—	—	4	—	—	—	—	—	5
General Divergency for hair colour	3	1	1	0	0	7	1	3	1	0	2	1
Blue ...	—	—	—	—	—	—	5	—	—	—	—	—
Light ...	4	—	—	—	—	—	—	—	—	—	—	—
Medium ...	—	—	—	—	7	4	—	—	—	7	3	—
Dark ...	3	3	—	—	3	7	—	4	—	—	—	—
General Divergency for eye colour	3	2	2	1	7	7	1	1	0	3	2	0

GIRLS.

	Anderston	Milton	St Rollox	Dennistoun	Bridgeton Group	Tradeston Group	Partick	South Govan	S. S.	E. S.	N. S.	W.S.
Fair ...	—	—	—	—	—	—	—	—	—	—	—	—
Red ...	—	—	—	—	—	—	—	—	—	2	—	—
Medium ...	3	—	4	4	6	7	5	9	4	—	3	—
Dark ...	6	6	3	—	5	9	—	—	—	—	—	—
Jet Black ...	—	—	—	—	—	—	—	—	—	—	—	6
General Divergency for hair colour	6	4	2	2	7	7	3	7	2	0	1	2
Blue ...	—	—	—	—	—	—	6	—	—	—	—	—
Light ...	—	—	—	—	—	—	—	—	—	—	3	—
Medium ...	—	—	—	5	7	4	—	—	—	6	—	—
Dark ...	3	3	—	—	—	5	—	3	—	—	—	—
General Divergency for eye colour	0	1	2	2	7	7	3	4	0	3	1	1

Differences between 2·5 and 3·5 are here class 3; between 3·5 and 4·5 class 4; between 4·5 and 5·5 class 5 and so on. The object is to show the degrees of difference even in significant cases. In the general analysis of the whole country, all differences above 3·5 are shown as one class. In the maps however all differences above 3·5 are included in class 4, to be in conformity with the general scheme.

TABLE LII.

	Boys		Girls	
	Hair	Eyes	Hair	Eyes
Anderston ...	Medium, Dark	Light, Dark	Medium, Dark	Dark
Milton ...	Slightly red, Medium	Dark	Medium	Dark
St Rollox ...	Medium	—	Medium, Dark	—
Dennistoun ...	—	—	Medium	Medium
Bridgeton Group	—	Medium	Medium, Dark	Medium
Tradeston Group	Medium, Dark, Black	Medium, Dark	Medium, Dark	Medium, Dark
Partick ...	Medium	Blue	Medium	Blue
South Govan ...	Medium	Dark	Medium	Dark
South Area ...	Dark	—	Dark	—
East Area ...	—	Medium	Red	Medium
North Area ...	Medium	Medium	Medium	Light
West Area ...	Jet Black	—	Jet Black	—

the only excess in hair colour (scarcely significant) being that of the dark class? Finally there is the general problem of the colour characters of Glasgow. Why should this population differ so markedly in pigmentation from the general population of Scotland? This problem will now be solved as far as it can be solved from the data of the survey and other available information.

III. *Specific Elements in the Glasgow Population, causing Divergency.* (*a*) *Introductory.* In one of the previous sections (Section 9) it was proved (1) that excess of blue eyes, dark hair, and jet black hair, are associated with regions of excess of the Gaelic speaking population; and (2) that excess of medium or brown hair, medium eyes and dark eyes are associated with more densely populated regions, which in turn are also regions of excess of foreigners. This means, briefly, that blue eyes, dark, and jet black hair are probably typical of Gaelic speaking people* although of course all the other classes are represented in this population, and that brown hair is typical of densely populated areas which in turn have a proportion above the average of foreign immigrants.

(*β*) *The Gaelic Speaking Population.* Taking the Gaelic speaking population first, there is undoubtedly a large Scoto-Keltic or Highland element in Glasgow. At the last Census, no fewer than 18,279 persons could speak Gaelic and English in the city proper. This is equal to 9 per cent. of the total Gaelic speaking population. Taking Glasgow, Govan, Kinning Park and Partick, that is Greater Glasgow (without the environs), the Census shows that nearly 24,000 or 11·7 per cent., or more than one-ninth of the whole Gaelic population, is concentrated in the great western city. An analysis of the Census returns further shows Kelvinside, with 6·4 per cent.; Tradeston (Kingston Ward), with 5 per cent.; Milton (Park Ward),

* Gaelic speaking people are not associated with dense areas as a whole. The correlation is negative, $r = -\cdot 39 \pm \cdot 2$. The association with sparsely populated parts is therefore not very high.

with 4·9 per cent.; Anderston, particularly Sandyford Ward, with 4·8 per cent., to be quite in excess of the general average for Greater Glasgow, which is 2·6 per cent. of the whole population of the city. Govan is also in excess, having 4·4 per cent. of Gaelic speaking people in its population. One seems justified in inferring that such a population distributed over Glasgow would have a marked effect on the nature of the distribution of colour. Since Glasgow is significantly darker than the general population, since dark hair is significantly associated with the Gaelic speaking population, and since at least one-ninth of the whole Gaelic speaking population resides in Greater Glasgow, the conclusion is inevitable that the Gaelic speaking portion contributes largely to the significance of the excess of dark hair. It is not contended that this is the whole cause of the significant excess, but it is a prominent factor. But it may be argued that blue eyes are in defect in Glasgow generally and since blue eyes are also associated with Gaelic speaking people, their presence does not seem, on this hypothesis, to affect the character of the distribution. The answer is: it must be borne in mind that the combination of blue eyes and fair hair in one person, that is the blonde type, is in great defect in Glasgow, thus diminishing the proportion of blue eyes to a great degree. There are also large excesses of dark eyes to which it will presently be seen the foreign element contributes. These and other factors prevail over the Gaelic factor and the theoretical excess of blue eyes is converted into an actual deficiency in this class, with one exception only. This exception is the Kelvinside and Partick group. Here a highly significant excess of blue eyes appears with an excess of dark hair, thus revealing the presence of the Gaelic speaking portion as one of the predominant causes of the divergency in these districts, for it has already been observed that in Kelvinside alone 6·4 per cent. (the highest percentage in any district in Glasgow) of the population speak Gaelic. Presence of excess of light eyes among boys in Anderston deserves notice. While it has been observed that excess of blue eyes is associated with the Gaelic speaking portion generally, it must be noted that Argyll has in its rural population 62 per cent. of Gaelic speaking people and has a large excess of light eyes. Excess of this class is therefore a characteristic of a section of the Highlands as it has been shown also to be of Ayr and Galloway which are closely allied in blood to the Highlands as it formerly was in language. It is highly probable that county immigrants and their descendants from Argyll, Ayr and Galloway, are at the present time in excess of the general proportion in Anderston generally, thus disturbing the balance in favour of an excess of light eyes in the boy population. In addition to this, there is the Irish element. Beddoe's results, already quoted, show an excess of light eyes in the Irish compared with the Scottish figures of the present data. The Gaelic element does not however account for excesses of medium hair and dark eyes in Anderston, although it would account for the excess of dark hair and light eyes. The general analysis shows Perthshire and Forfarshire to have significant excess of dark eyes, which has been suggested to account for the similar excess in Dundee and perhaps to some extent to explain the excess of the same class in Edinburgh. Are county immigrants and their descendants from these regions in excess also in Anderston

and in Glasgow generally, for the excess of dark eyes is common practically over the whole of Glasgow although it is more highly significant in Tradeston, Govan, Anderston, Milton, and Bridgeton? I think this is unlikely. There must be some other factor or factors besides mere immigration from the Scottish Midlands. What are they?

(γ) *The Foreign Population of Glasgow.* It was shown in the last section that the correlation between foreigners and density of population was very high. It was so high that on comparing foreigners and density of population separately with pigmentation, the same conclusion was reached for each. It could not however be said whether foreign immigrants were causing the excesses in the three classes named by their great numbers or whether the excesses were there independently of them, for, since foreigners came mainly to towns, it might be only through density as the common link that the correlation existed at all. The association between foreigners and density is however real. Foreign immigrants are likely to be found to reside in greater numbers in the most densely populated areas and in the smallest houses. Now it is very suggestive that, at the last Census, 9644 foreigners or 42·6 per cent. of the total number of foreigners in Scotland (22,627 in 1901) resided in Glasgow alone. It is also suggestive that of the great cities Glasgow is by far the most densely populated. The following table gives the relative densities of the chief towns in Scotland:

TABLE LIII.

Number of Persons per Square Mile in the Chief Towns of Scotland.

Town	Persons per Square Mile	Town	Persons per Square Mile
Pollockshaws ...	43,177	Coatbridge ...	12,830
Greater Glasgow ...	39,331	Musselburgh ...	12,826
Leith ...	33,787	Alloa ...	12,661
Rutherglen ...	30,537	Kirkcaldy ...	12,515
Dundee ...	28,069	Barrhead ...	11,916
Johnstone ...	27,859	Dumbarton ...	11,387
Port Glasgow ...	24,289	Falkirk ...	11,223
Motherwell ...	21,978	Perth ...	11,031
Edinburgh ...	20,089	Peterhead ...	10,991
Greenock ...	18,598	Inverness ...	10,514
Fraserburgh ...	17,510	Galashiels ...	10,085
Kilmarnock ...	17,125	Ayr ...	9,177
Hamilton ...	15,750	Brechin ...	9,086
Aberdeen ...	15,716	Stirling ...	8,552
Clydebank ...	14,959	Dunfermline ...	8,016
Dumfries ...	14,726	Kirkintilloch ...	7,992
Wishaw ...	14,535	Forfar ...	7,444
Bo'ness ...	13,889	Montrose ...	5,422
Airdrie ...	13,598	Renfrew ...	3,742
Hawick ...	13,434	Irvine ...	3,429
Arbroath ...	13,075	Rothesay ...	2,461

TABLE LIV.

Population in 1901 *of the Chief Towns in Scotland arranged in the order of their magnitude.*

Town	Population	Town	Population
Greater Glasgow ...	906,391	Stirling ...	18,403
Edinburgh ...	316,837	Hawick ...	17,303
Dundee ...	161,173	Port Glasgow ...	16,857
Aberdeen ...	144,117	Rutherglen ...	16,185
Leith ...	77,439	Galashiels ...	13,615
Greenock ...	68,142	Dumfries ...	13,092
Coatbridge ...	36,991	Montrose ...	12,427
Kilmarnock ...	34,165	Peterhead ...	11,794
Kirkcaldy ...	34,079	Musselburgh ...	11,711
Perth ...	32,873	Alloa ...	11,421
Hamilton ...	32,775	Forfar ...	11,397
Motherwell ...	30,418	Pollockshaws ...	11,183
Falkirk ...	29,280	Johnstone ...	10,503
Ayr ...	28,697	Kirkintilloch ...	10,502
Dunfermline ...	25,250	Barrhead ...	9,855
Arbroath ...	22,398	Irvine ...	9,618
Airdrie ...	22,288	Rothesay ...	9,378
Inverness ...	21,238	Bo'ness ...	9,306
Wishaw ...	20,873	Renfrew ...	9,296
Dumbarton ...	19,985	Fraserburgh ...	9,105
Clydebank ...	18,670	Brechin ...	8,941

From the results found in ascertaining the degree of association between density and pigmentation, excesses of medium hair, medium eyes and dark eyes would be expected in Glasgow. But the most densely populated parts of the city have been proved to be likely to contain more foreigners than the less densely populated parts. Thus the greater the number of persons per square mile a population has, the greater will be the expected excess of the three classes associated with excess of foreign immigrants. Now the only large group which has the complete density-colour specification (and in the greatest excess) and which has the highest general divergency, is the group of divisions Tradeston, Gorbals and Hutchesontown. It is highly probable that the foreign element may be one of the factors in the divergency of this group—foreign immigrants may contribute to the excesses in one or more of the classes there. In order that an estimate of the probable number of school children of foreign parentage attending Glasgow schools might be formed, an enumeration of those possessing foreign surnames was made. At the same time the colour characters were noted and classified. Only those surnames which were unmistakably foreign were taken, so that the estimate is most probably below instead of above the actual figures. The following is the result of the enumeration for the various pigmentation groups of Greater Glasgow. The environs were not included.

TABLE LV.

Division or Group	Children in each division having foreign surnames, per cent. of the total number of children in Greater Glasgow having foreign surnames
Anderston	12·51
Milton	7·78
St Rollox	1·28
Dennistoun	7·98
Calton, Camlachie and Bridgeton	3·85
Tradeston, Gorbals and Hutchesontown ...	59·21
South Govan	6·50
Partick and Kelvinside	·89
Totals	100·00

This result is striking and confirms what has been said as to the Tradeston group. In two schools alone, Gorbals and Adelphi Terrace, about 500 children had distinctly foreign, mostly Jewish, surnames. The colour characters of these children were tabulated with the following result (Table LVI.):

TABLE LVI.

Children with Foreign Surnames

Colour	Gorbals per cent.	Adelphi Terrace per cent.
Hair:		
Fair ...	3·14	8·00
Red ...	1·04	2·29
Medium ...	37·98	26·29
Dark ...	53·31	56·57
Jet Black ...	4·53	6·86
Eyes:		
Blue ...	3·14	1·71
Light ...	17·42	17·71
Medium ...	21·25	18·86
Dark ...	58·19	61·71

In Gorbals Public School 41 per cent. and in Adelphi Terrace Public School 44 per cent. of the children of foreign parents had dark hair associated with dark eyes in the same individual. Thus the Jewish element alone in the Tradeston group is sufficient to account for the excesses in dark hair, jet black hair, and dark eyes, found in this populous district.

It has been directly ascertained that the foreign element in the Tradeston group is largely made up of Jews of Russian and Polish origin. From the Census Report it is seen that of the whole number of foreigners in Glasgow, 60 per cent.

are Russians and Poles; 15 per cent. are Italians; 10 per cent. belong to other races whose predominant hair colour is known to be brown or dark. Only 15 per cent. belong to Northern races or peoples likely to have a moderate or large proportion of the blonde type, namely, Germans, Swedes, Norwegians, Dutch and Belgians. Thus wherever foreigners congregate together in the city anywhere they are likely to increase the darkness of the population rather than otherwise. The general effect outside the Tradeston group may be small, since the foreign population is more scattered, and is in much smaller proportion consequently in every division but Tradeston and Gorbals. Any effect Italians have would be in the direction of excess of medium hair and dark eyes since Livi* has shown these are the typical classes among Italians, but there is no evidence of the concentration of members of this race as a group in the city†.

(δ) *The Irish Population of Glasgow.* The Gaelic speaking population has been shown to be likely to influence the colour distribution of Glasgow in the direction of excess in the dark and jet black haired classes and also probably in the blue-eyed and light-eyed classes. The divisions likely to be influenced have also been pointed out. But there is another very important element in the Glasgow population still to be considered. It is estimated by reliable authorities that there are about 100,000 Irishmen in Glasgow. Over 40,000 as a minimum are Protestants‡. The proportion of persons of Irish origin in other parts of Scotland is very small. The effect of this large population, if its colour characters differed from those of the Scottish population, would be very great. In one of the previous sections (Section 9, Table XXXVIII.) it was pointed out from Beddoe's figures that compared with Scotland, Ireland was likely to have much higher proportions of light eyes (light and blue, however; Beddoe grouped both together as one class), dark hair and jet black hair. Beddoe's figures of course refer to the adult Irish population. It therefore seemed desirable to get an estimate of the distribution of colour among Irish children. The colour characters of school children, stated by the teachers to be of Irish origin, in certain Glasgow schools were tabulated, when the figures given in the accompanying table (Table LVII.) were obtained.

These figures confirm the conclusion from Beddoe's results. Dark and jet black hair are both in excess compared with the Scottish population. The distribution therefore differs markedly from the general Scottish distribution. If children of Irish origin were present in a moderately large proportion in any of the districts, they would sensibly affect the colour distributions in the schools of Glasgow. In order to gain some information as to the number of children of Irish origin in each of the pigmentation districts of Glasgow, the author recently communicated with the headmasters who very kindly sent in a return showing the numbers approximately of children of non-Scottish origin, in three classes: (*a*) foreign, (*β*) Irish,

* R. Livi, *Antropometria Militare*, Roma, 1898.

† Canon Ritchie has very kindly supplied me with figures from the Roman Catholic Clergymen of Glasgow which show that Italians are nearly in even proportions in the various divisions.

‡ This estimate is based on figures supplied by Orangemen, through the kindness of Mr Hugh Berrie, Glasgow.

TABLE LVII.

Colour Distribution of Children of Irish origin.

	Per Cent.		Irish Adults
	Boys	Girls	Beddoe
Hair:			
Fair ...	24·31	22·11	10·4
Red ...	4·53	5·09	4·6
Medium ...	40·32	35·13	33·4
Dark ...	27·26	33·07	40·5
Jet Black ...	3·58	4·60	11·0
Eyes:			
Blue ...	22·53	21·23	66·5
Light ...	26·52	26·03	
Medium ...	28·84	28·38	14·7
Dark ...	22·11	24·36	18·6

(γ) English and Welsh. The following table (Table LVIII.) shows the percentages of each of the three classes based on the returns received. The author desires cordially to thank the teachers of Glasgow for supplying the additional information asked for—information which assists in the verification of some of the conclusions as to the cause of the great divergency of the population of Glasgow from the general population.

TABLE LVIII.

Percentages of Children of Non-Scottish Origin. Glasgow Proper.

Division	Number of Children of Origin as noted below in Public Schools sending returns		
	Per Cent. Foreign	Per Cent. Irish	Per Cent. English
Anderston	·68	6·61	3·39
Milton	1·16	4·29	4·90
St Rollox	·67	7·99	6·42
Dennistoun	·15	9·35	5·80
Calton, Camlachie and Bridgeton	·24	5·15	4·36
Tradeston, Gorbals and Hutchesontown ...	8·18	3·72	3·08

This table does not of course represent the absolute percentages of non-Scottish children in the above named divisions. Practically the whole of the children attending Catholic schools are excluded. The percentage of Irish school children in each division is really much higher. The above table merely shows the proportion in the public schools sending returns. The table serves its purpose as

showing the large Irish element in the public schools of Glasgow—an element which, from the results of the analysis of the colour characters of Irish school children in Glasgow, tends to make the hair colour distribution of the western city darker than the remaining Scottish population. The school children of Irish origin have on an average 2 per cent. more of the dark-haired class (boys) and about 8 per cent. more in the girl population. A distinctly greater proportion belong to the jet black class among the Irish population, about 4 per cent., compared with $1\frac{1}{4}$ per cent. in the Scottish population. Although a greater proportion of the Irish population observed, compared with the general Scottish population, has blue eyes, this class does not appear in excess in any of the populous centres except Partick. Partick was not included nor was Govan in the investigation as to the number of school children of non-Scottish origin—an omission which the author regrets he made when the Glasgow teachers were invited to send the additional returns. Further work is contemplated on the Glasgow returns and an additional return is expected from many of the large Catholic schools. These schools have an attendance of about 20,000 children whose colour characters have not yet been observed. A very large number of these children are of Irish origin and a knowledge of their colour distribution will be useful. Of course since these children were not included in the present survey, they do not contribute to the divergency found for Glasgow.

The results of this subsection show that children of Irish origin clearly affect the nature of the distribution of colour in Glasgow. They tend, as the Scoto-Keltic and the foreign populations do, to create an excess of dark hair and jet black hair. The Irish population does not appear to affect the eye colour distribution of Glasgow sensibly. It may however do so. Other factors which have not yet been discovered may be operating to obscure the effect of the Irish element on the distribution of eye colour in the western city.

The association of excess of dark hair, jet black hair, blue eyes and light eyes with the Scoto-Keltic and Irish populations is a striking feature in these results. The results but confirm the common origin of the two peoples—their association as determined by language, by history and by tradition.

IV. *Summary of this Section.* (1) The general analysis reveals Glasgow to diverge largely from the general population both in hair colour and eye colour.

(2) Further analysis shows the divergency to be due to excesses of the medium and dark haired classes and the medium and dark eyed classes, and to defects of the fair-haired and blue-eyed classes.

(3) Analysis of the divisions into which Glasgow is divided brings out the fact that the excesses are not uniformly distributed over the city. No excess of the fair-haired class appears in any quarter of the city, but certain districts, St Rollox (♂), Dennistoun (♂), and the western suburban area (Paisley) have about the average proportion of this class. Milton, the Cowcaddens district, is the only one showing excess—a slight one—of the red-haired class. Excess of medium hair in varying

proportions occurs in every district of the city. In St Rollox, Dennistoun, Calton and Bridgeton, the excesses are not so marked in the boy population. Excess of dark hair is characteristic in a marked degree of Anderston and Tradeston, Gorbals and Hutchesontown. In other densely populated centres the girl population also shows excesses of this class. Jet black hair is in excess in the Tradeston group. Blue eyes is in excess only in the Partick group; light eyes in Anderston; medium eyes in Dennistoun and the Bridgeton and Tradeston groups; dark eyes in Anderston, Milton, Govan and the Tradeston group.

(4) The environs of Glasgow diverge in a much less degree from the general population. The population is not so dark as in the city.

(5) The deficiencies in the blue-eyed and fair-haired classes are due to the presence of a complex group which, with a darker colour specification, creates deficiencies in these classes. This complex group includes Highland, Irish, and foreign populations.

(6) It cannot be said from the data whether these classes (fair hair; blue eyes) are less fitted for town life or whether this theory would account for any of the low percentages of these classes. The low percentages are on the other hand explained by the presence of the darker Scoto-Keltic and non-Scottish elements.

(7) The Scoto-Keltic, Highland or Gaelic speaking population appreciably affects the distribution of colour and helps to explain excesses in dark hair and light and blue eyes.

(8) The Irish population, a very large one, also helps to explain the large excesses in dark and jet black hair and probably light eyes where they occur.

(9) The foreign element helps largely to explain why Tradeston and Gorbals diverge so widely from the rest of the population. The presence of other non-Scottish groups in this part of the city is probable.

(10) The country north-east and almost contiguous to Glasgow might contribute in some degree to excess of dark eyes, since these parts (Stirling, Perth, etc.) have an excess of this class in their own populations. The greater fertility of the lower classes, and of the dark-eyed portion particularly, might contribute to explain the excess of this class.

(11) Excess of medium hair and medium eyes cannot be accounted for by the presence of a Scoto-Keltic element or of a non-Scottish element or by the migration of excesses of Scottish members of these classes from rural districts to the city. Excesses of these classes are not found to any extent outwith densely populated centres.

(12) The excesses may be due to blending of fair and dark populations or to greater fertility of the medium classes, or to both these causes.

(12) *Comparison with other Data.*

I. *Scottish Data.* (α) *East Aberdeenshire Children in* 1896. The only data of a similar character with which any of the results of the present survey can be at all compared are the East Aberdeenshire results of 1896 published in a preliminary paper by the author in 1897*. Owing to slightly different ranges in some of the classes however the results are not directly comparable, as printed, with the results for East Aberdeenshire in 1903, when the general pigmentation survey was carried out. Fortunately in 1896, the teachers were asked not only to record the colour with reference to the classes then adopted but also to note where possible, and always if in doubt, the probable sub-class from a series of stated sub-classes, similar to Broca's scale. Thus the author has been able to retabulate where necessary the results of 1896 and, as far as possible, place the children in the classes as specified in the analytical tables of the present survey. The first survey, it has been found, had a wider range of medium and a slightly wider range of red. With respect to the eye classes, the blue and light-eyed class of 1903 corresponds pretty closely to the light-eyed class of 1896. The following table (Table LIX.) shows the relative differences in the classes between the two sets of observations. To be more specific, the table shows the difference per cent. (or d) in each class compared with the probable error of the percentage difference, that is, compared with

$$E_d = 67{\cdot}449\sqrt{\frac{pq}{m}+\frac{p'q'}{n}},$$

where in this formula, $p=\frac{y}{N}$; $q=(1-p)$; $y=$ observed frequency of the class in

TABLE LIX.

Relative Difference between East Aberdeenshire in 1896 *and* 1903. (*Boys and Girls.*)

Colour		$\frac{d}{E_d}$
Hair:		
Fair	...	1·77
Red	...	−2·05
Medium	...	−6·79
Dark	...	6·28
Eyes:		
Light	...	6·29
Medium	...	−1·74
Dark	...	−3·78

* Tocher: *Trans. Buchan Field Club*, Vol. IV. pp. 137—152.

the first sample; m = number in first sample, $p' = \frac{y'}{N'}$; $(1-p') = q'$; y' = observed frequency of the class in the second sample; n = number in second sample; N = total children in first sample; and N' = total children in second sample.

The negative sign indicates that the proportion of the class considered was less in 1903 than in 1896 and the positive sign that it was greater. The above results seem to indicate that the school population of East Aberdeenshire became darker haired to an extent which must be reckoned significant, and lighter eyed to an extent also significant in the eight years' interval. Making allowance for any difference in method of observation, and comparing parish with parish, the results are however very similar. The difference lies chiefly in the results from the two towns in the division, Peterhead and Fraserburgh.

(β) *Scottish Adults—The Insane.* The colour results of the survey of asylums in Scotland are not directly comparable, since the observations were made on adults and since the group is a selected one and is not truly representative of the general population. All one can do is to note in a general way the agreement or otherwise of the two sets of data. The author has not found it possible to spare the time to estimate from the juvenile data the probable distribution of the ordinary adult population in each division or to deal in further detail with the colour characters of the insane. Moreover it seems more desirable—more satisfactory—to wait until the adults of the normal population are directly surveyed. Instead of the promised detailed comparison between the two sets of data, it seems sufficient to point to the leading features. Both sets of data agree in showing less divergency in densely populated parts. The excess of dark hair in the west found for the asylum population has been amply confirmed by the results of this survey. The region of excess of dark eyes in the asylum population has proved to be the same region for the general school survey. Perthshire, Stirling and Forfar are the counties constituting this region. The excess of medium hair is in both associated with density. The proportions of fair hair and red hair are small compared with the juvenile population. Excess of light eyes is somewhat similarly distributed, but is not so much south-west as the juvenile distribution. The region of excess of red hair is quite the same. Briefly, while it would be useless to compare the relative frequencies of the two sets of data for the reasons already stated, still when the local class frequencies of each set are compared with each set's own general population, they show on the whole the same significance. It has been shown that the colour distribution of the insane population as a whole cannot represent the general distribution of the sane in one important particular, namely, in the frequency of the light-eyed class. Regions of excess of insanity from the general average are associated with regions of excess of light eyes, thereby increasing the proportion of light eyes in the general insane population beyond the expected amount for the general adult sane population*.

* *Biometrika*, Vol. v. pp. 298—350.

(γ) *Scottish Adults—Beddoe's Observations.* The figures of the pioneer observer Dr Beddoe are useful, indicating as they do the predominant classes in various localities in Scotland. The samples of the population observed by Beddoe are usually small and in many cases they are too local to give an idea of the distribution of the surrounding area. His classes do not all correspond to those of the present data, and since adults and not children were observed by him one is farther debarred from attempting to compare directly the relative frequencies of his classes in various localities with those from this survey. The proportion of red hair generally found by him appears to be slightly higher than that found by the teachers of Scotland among the children. The excesses however appear in the same districts. He shows excess of dark hair in the same western regions of the country. The proper time to enter into a discussion of Dr Beddoe's results is when a survey of the colour characters of the adult population has been completed and the results tabulated and analysed.

II. *Foreign Data.* (α) *The Actual Data.* The results of this survey will now be compared with the results of the surveys of the colour characters of children which have been carried out in Germany, Switzerland and (partially) in England, and with the results of the surveys of the colour characters of the adult populations of Sweden and Italy (military data). The following table (Table LX.) gives the percentages of the classes in each of the countries named, the school figures for Scotland being given alongside for comparison.

TABLE LX.

Authority	Country	Nature of Population	Hair				Eyes		
			Fair	Red	Medium	Dark	Light	Medium	Dark
Virchow ...	Prussia	Children	72·4	·3	26·0	1·3	42·9	32·6	24·5
Beddoe ...	Switzerland		52·9	2·9	38·9	5·3			
Retzius ...	Sweden	Adults	75·3	2·3	21·6	·8	66·7	28·8	4·5
Livi ...	Italy	Military	8·2	·6	60·1	31·1	10·3	20·6	69·1
Ammon ...	Baden	Adults	41·6	1·7	38·6	18·1	64·4	22·9	12·7
Tocher ...	Russian Jews in Glasgow	Children	5·1	1·2	33·4	59·7	19·8	21·1	59·1
Pearson ...	England	Boys	33·5	4·1	34·0	28·4	41·5	37·0	21·6
Tocher ...	Scotland	Boys	24·95	5·49	43·28	26·28	44·97	32·72	22·31
„ ...	„	Girls	27·43	5·09	40·87	26·62	45·18	32·06	22·76

(β) *Comments.* The first fact worthy of notice is that Scotland occupies an intermediate position between the extreme northern race (Germany) and the extreme southern one (Italy) in the matter of pigmentation. The northern German race has about 72 per cent. of the fair-haired class; the Italian race about 60 per cent. of the brown-haired class and 31 per cent. of the dark-haired class. Scotland has about equal proportions of fair and dark; about one-fourth of the school population is either fair-haired or dark-haired; the remaining belong to intermediate classes which include the shades of brown and red. Now if a pure race of the blonde

type is defined as meaning a population which has been isolated and has bred within itself in an environment unsuitable for the production of hair pigment for a sufficient length of time to ensure that every individual will be fair-haired, it is obvious none of the northern races are pure races of the blonde type. They have relatively large sections in their respective populations which are pigmented. Similarly if by a pure race of the dark-haired type is meant a population which has bred within itself in an environment suitable for the production of hair pigment for a sufficient length of time to ensure that every individual was uniformly pigmented dark, it is clear the southern Italian race is not a pure race of the dark-haired type. The Italian people are largely of the brown or intermediate type (about 60 per cent.); 31 per cent. or nearly one-third are dark; about 8 per cent. are fair. If all the races of mankind were uniformly pigmented or non-pigmented, hair colour would cease to be one of the tests of race. But this is not the case and the problem is: how far can one use colour as a test of race or of racial purity? One must in the first place consider whether in conjugal unions between the fair and dark types blended or exclusive inheritance holds, or whether both exist. It is clear from observation that blended inheritance does exist for fair and dark hair colours, the shades of brown being the blend. What is wanted is a measure of the blended inheritance in this case. From observation it is possible that exclusive inheritance exists in the case of red hair. But the main point here is that, in hair colour, one has a problem in blended inheritance. Now granting equipotency of the two types, fair and dark, and random mating with respect to hair colour as well as other forms of mating as probable, and it is obvious that varying proportions of fair, dark and the shades of brown hair will occur in the population of a country according to the proportions of the fair and dark types originally settling in that country. Is anything known of an exact nature as to the distribution of colour in the offspring of fair and dark parents, i.e. of parents one dark and one fair? Insufficient data exist to show the exact nature of the distribution. A large number of carefully made observations are required. Individual cases can be cited. (A) Dark-haired, and (B) fair-haired, have a family of five. One is fair, one is dark, three are medium. All are children, but the oldest, classed medium, is getting darker and will probably be dark. To be accurate one must compare the colour of the parents *when they were children* with the colour of the offspring *as children*; or the colour of the parents with the colour of the offspring *as adults*. Can it be said that the most probable distribution of colour in the offspring of such parents, granting blended inheritance and equipotency in determining pigment, is, in say a family of four, 1, 2, 1; one fair-haired, two medium and one dark-haired? The object of science is to give a shorthand description of the facts. In this case the expanded binomial $(\frac{1}{2} + \frac{1}{2})^2$ is put forward tentatively as the shorthand description. If true it is a problem like determining the number of times two heads, one head and no heads, will turn up in spinning two coins together. The most probable distribution in this case is, 1, 2, 1. Can hair colour in Scotland be cited as an example of this simple binomial distribution, similar to the Mendelian example in the crossing of peas? This has to

be determined. What the writer wishes to lead up to is this. In Scotland the distribution of colour is roughly, 1 fair, 2 mixed, and 1 dark. Is it fair to infer that the original elements of the Scottish population were fair-haired and dark-haired races in approximately equal proportions? Proof is wanting but the distribution is suggestive. From our knowledge of the distribution of eye colour in Scotland, it is unlikely that although there were fair-haired and dark-haired races, the two elements were entirely blonde and brunette—the blue-eyed fair-haired type, and the dark-eyed dark-haired type. It cannot be shown from the data what proportion of the *dark-haired* element was of the brunette type or what proportion was of the type found in the Gaelic speaking population, the *blue or light-eyed dark-haired* Keltic type. Who were our ancestors of the brunette type? Were they of the Mediterranean or Danish type or both? The fair-haired element probably was made up of the blonde type, Scandinavians and others of Germanic stock who, history tells us, came to our shores in bygone centuries and who fought, struggled, settled and made Scotland—the Scotland of the dark-haired Kelt—their home. Together with the darker elements they may have united and appear to be now uniting to form a blend—the Scottish type—one which in physical characters has proved itself vigorous and which, considering mental characters, has been at least relatively as productive of men of ability as any in the British Isles.

III. *The Data bearing on correlation, and comparison with similar data.* (*a*) *General.* Hitherto, throughout the entire course of this investigation, the author has been considering hair colour and eye colour separately—taken one at a time. It is obvious however that an account of the colour characters of the Scottish children would be incomplete which did not include an investigation on the two taken together as found occurring in each individual.

It is one of the disadvantages of a private investigation as compared with an official one carried out by a Department of the State, that an adequately paid staff is not available to tabulate the enormous mass of data, the complete analysis of which is necessary before a full account can be given of all the facts which flow from the results and which lie hidden until the tabulation has been made. Although the author has been continuously engaged in the tabulation and numerical treatment of the returns so kindly made by the teachers voluntarily more than four years ago, he has been able only to complete the investigation in so far as it refers to the separate colour characters. The large mass of data bearing on fraternal and other relationships lie practically untouched. The tabulation of the combinations of the two characters has still to be made, except for one or two districts. The author has complete confidence that not only will he be able to get the funds necessary for clerical assistance to tabulate these important data, but that he will be personally given sufficient time to do the work. The correlations between hair and eye colour when such data are tabulated and the values of the correlations evaluated for each locality will be of great value. Not only will the predominant types in each district be determined but the relative homogeneity

of each group will be accurately ascertained. Again, there are the colour characters of groups of families as revealed by surnames to be considered. A tabulation and analysis of the colour characters of surname groups for each surname would show whether they were really associated, like family groups, or were merely samples of the general population. The degrees of resemblance of brothers and sisters would be determined on numbers hitherto undealt with and would confirm or otherwise the measures found from the numerically smaller English data. Finally, the degrees of resemblance between the various kinds of cousins, an investigation suggested to the author by Professor Karl Pearson, await determination*, and the determination cannot be made until the almost overwhelming mass of data bearing on cousinships has been also tabulated.

(β) *Comparisons.* The correlation between hair and eye colour has been determined, the contingency method being used, for one Scottish group, namely, 19,279 school children of the city of Aberdeen, and also for 1000 children taken at random from the entire pigmentation data. The following two tables give respectively (Table LXI.) the results of the observations of hair and eye combinations in the city of Aberdeen, and (Table LXII.) the values of the contingency coefficients. The author's results for other Scottish populations and those from British and continental returns are given alongside for the purpose of comparison.

TABLE LXI.

Hair and Eye Table. 19,279 *Children in the City of Aberdeen.*

Eyes.	Hair. Fair	Red	Medium	Dark	Jet Black	Totals
Blue ...	1105	131	885	348	1	2470
Light ...	2285	405	2434	851	9	5984
Medium ...	1208	360	3242	1601	29	6440
Dark ...	366	209	1621	2094	95	4385
Totals ...	4964	1105	8182	4894	134	19279

These results show, if it is a mark of racial purity of any race to have its individuals all of one hair colour and of one eye colour, that the Prussian school children are relatively more homogeneous than the Scottish school children, and that the latter in turn are more homogeneous than the British schoolboys generally, since the value of the correlation is lowest in the case of the Prussian children and highest in the case of the British schoolboys. It may be here noted that if two races, one of the blonde type and one of the brunette type, were present in a population in equal proportions, the degree of correlation between hair colour and eye colour would be equal to unity. On the other hand, (1) the

* The author intends to hand over the classified data on cousinships to Professor Pearson as soon as they have been abstracted and tabulated.

TABLE LXII.

Correlations. Hair and Eyes.

Population	Contingency Coefficient	Returns by	Reference
Scottish Children, General, 1903	·3453	J. F. Tocher	This Memoir
Scottish Children, East Aberdeen, 1896 ...	·3802	"	"
Scottish Children, Aberdeen City, 1903 ...	·3361	"	"
British Schoolboys	·4203	K. Pearson	*Biometrika*, Vol. III. p. 461
Prussian Children	·2714	R. Virchow	" "
Jewish Children	·3381	"	" "
Adult Scottish Population	·3673	J. F. Tocher	*Biometrika*, Vol. v. p. 339
Male Asylum Inmates	·3039	"	" "
Female Asylum Inmates	·2994	"	" "
Swedish Conscripts	·2495	G. Retzius	*Biometrika*, Vol. III. p. 461
Italian Conscripts	·3091	R. Livi	" "
Baden Conscripts	·3540	O. Ammon	" "
Mean of above values	·3312		

more this population in time and through intermarriage was thoroughly crossed, or (2) the nearer this population came to consist of members entirely of either race, the smaller would be the value of the correlation and the nearer it would approach to zero. Looked at from this point of view, a large value for the correlation would mean heterogeneity in that population and a small value greater homogeneity.

Judging from the above results, the correlation between hair and eyes does not appear very close in any of the countries. With more local groups it is probable that in countries like Prussia and Italy less association would be found.

In the further investigations on the data of this survey, it will be interesting to find what values the correlation coefficients take in the various districts; particularly (α) in those where one type has been found to be predominant, and (β) in those sparsely populated parts where two diverse types were found.

(13) *Summary of the Results.*

I. The general result of the Pigmentation Survey of School Children in Scotland shows that, of the 502,155 children surveyed, about one-fourth are fair-haired, one-fourth dark-haired, and nearly one-half belong to two intermediate classes embracing the various shades of brown or medium and red hair. The proportion of the brown or medium class in the boy population is about 43 per cent., and in the girl population 41 per cent. The class embracing the various shades of red hair constitutes about 5 per cent. of the population. In the dark-haired group there are two classes—a large class with dark brown hair approaching to black,

and a small class with jet black hair. This latter class constitutes only 1¼ per cent. of the total population. The girl population contains a higher proportion of the fair-haired class than the boy population, over 27 per cent. as against 25 per cent. There is a correspondingly less proportion of the medium or brown-haired class in the girl population. The cause of this difference is not quite apparent. It should be remembered that the children surveyed are those of school age—a fairly wide range, from 6 to 18—and that hair colour in children gets visibly darker as the children get older. If the children were classed according to age and their colour characters tabulated, it would be ascertained whether or not the difference was due to an earlier darkening in hair colour among the boy population, or whether the boy population was really significantly darker in hair colour from infancy than the girl population. From the results of observations of the physical characters generally of both sexes, a really significantly darker boy population from natural causes is improbable. It should moreover be remembered that, in determining hair colour, boys and girls are not judged exactly under the same conditions. Hair colour in girls is generally judged from long tresses. These are usually absent in boys, whose hair colour is judged from the shorter mass. Besides, girls' hair frequently shows extreme variety of tint from tip to root. Another possible explanation is the stimulus given to the increase of pigment by hair cutting in the boy population. This explanation requires verification from observations, (α) on a population of children in which the conditions are the same, and (β) on the adult population.

The results of the observations on eye colour show that over 22 per cent. (nearly one-fourth) of the school children of Scotland have dark brown or dark eyes, and over three-fourths of the population possess blue, light or medium eyes. About 15 per cent. possess pure blue eyes, 30 per cent. light eyes, and about 32 per cent. (nearly one-third of the population) possess eyes of the mixed type —the varieties classed as medium eyes.

Comparing these general results with the results of similar surveys in foreign countries, it is seen that they differ markedly in many respects. In Northern Europe, between the same latitudes as Great Britain lies from Frankfurt, Prague and Cracow in the south to Christiania, Stockholm and St Petersburg in the north, one finds a heterogeneous population in which the fair-haired class predominates. In Prussia alone, 72 per cent. or nearly three-fourths of the children are fair-haired. In Sweden, a similar proportion of the adults are fair-haired. In Schleswig, 80 per cent. of the children are fair-haired; in Saxony, 69 per cent. Germany, south of Frankfurt and Coburg, is distinctly darker than the northern and larger portion. But even in South Germany the proportion of the fair-haired class far exceeds that found in Scotland. In Alsace and Lorraine the proportion is 47 per cent.; in Baden 58 per cent.; in Würtemberg 62 per cent.; and in Bavaria 54 per cent. The difference in the distribution of eye colour is not so marked. Prussia is somewhat similar to Scotland in its eye colour, the proportions being in Prussia 43, 33 and 24 as against 45, 33 and 22 in Scotland for light,

medium and dark eyes respectively. Germany as a whole has a significantly greater proportion of dark eyes than in Scotland, 32 per cent. as against 22 per cent. Scotland does not resemble Italy in any respect, except that in both medium is the predominant class in hair colour. In Italy, however, the proportion is significantly greater, 60 per cent. as against 43 per cent. in Scotland. Nowhere on the Continent does one find a distribution of hair colour similar to Scotland. It remains to be seen, when observations are made on English, Welsh and Irish children, in what respects these will differ from the results for Scottish children as shown by this survey. The difference between Pearson's series of 4000 children and Scottish children is not very great.

II. The results of this survey show that the distribution of colour is by no means uniform throughout Scotland. On the contrary, there are well-defined areas where the proportions of the various classes exceed quite significantly the proportions which would occur if the population were as evenly distributed throughout Scotland as, say, the grain of a cornfield is sown by the farmer. In this example, the distribution of the grain is not *absolutely* uniform, but the farmer succeeds in preventing excessive deposits of grain in one part and meagre deposits in another. An enumeration of the number of seeds in each square yard, and an analysis of the numbers would show that the *intention* had been to make a uniform distribution. No such uniform distribution of the population of Scotland is found when the population is considered in sections as represented by the various colour classes. This is quite apart from the density of the population, which is well known to be very far from being uniform. The *proportions* of the various classes quite exceed in the expected values in many localities.

Excesses of blue eyes and fair hair occur mainly in the north of Scotland and are common for both sexes to Orkney, Shetland, the isle of Lewis, Ross, Cromarty, Elgin, Nairn and Perth, and portions of Stirling, Forfar and Fife; also to Ayr and portions of Renfrew and Lanark in the west and Berwick in the east; in all representing only about 1,000,000 of the population; that is, about one-fifth of the whole population of Scotland has a significantly greater proportion than the average of the fair-haired and blue-eyed classes, the excesses being common to both sexes. In the girl population the distribution of excess of both classes is greater; it extends to a population of nearly two millions in the case of fair hair and to about a million-and-a-half in the case of blue eyes. The distribution of red hair is fairly uniform throughout Scotland. The region of marked excess for a large area is the north-east of Scotland. Isolated cases of excess occur in Sutherland and in the north-east of Lanarkshire. Excessive proportions of medium or brown hair occur in Glasgow, Govan, Dundee, and in the counties of Renfrew, Selkirk and Peebles. The excess in Leith for the boy population is also probably significant, as also the excesses in the counties of Stirling (girls), Linlithgow and Bute (boys). Excess of this class (see VII.) is peculiar to densely populated districts. Excess of dark hair is peculiar to the west of Scotland, the only eastern county showing excess of this class (boys only) being the small county of Kin-

cardine. The counties of Inverness and Argyll, and the city of Glasgow, show excess of this class for both the boy and girl populations. Kirkcudbright and Sutherland (boys), and Renfrew (girls), also show significant excess. The west is also the region of excess of jet black hair, a small class numerically. Altogether there are only about 6000 children out of a total of over 500,000 who possess jet black hair. The excess is common to both sexes in the counties of Perth, Inverness, Ross and Cromarty. Caithness (boys) and Argyll (girls) also show significant excess. Excess of blue eyes has already been stated to be common to the north. Significant excess of light eyes is common to Argyll and Dumbarton in the west and to Leith in the east. Kincardine and Kirkcudbright both show significant excess of this class in the girl population. Significant excess of medium eyes is peculiar to the great cities, Glasgow, Aberdeen (girls), Leith (girls), and Dundee (girls); and to the county of Lanark generally. Significant excess of dark eyes is also peculiar to the great cities, Glasgow, Edinburgh and Dundee. The county of Forfar shows significant excess for the girl population.

III. Many parts of Scotland quite resemble the general population in hair colour and eye colour. These parts are usually densely populated. Notable exceptions occur. Glasgow is the striking example. The presence of non-Scottish elements and of excess of the Highland element makes Glasgow unrepresentative. The populous East-Midland division is most representative of the general population in hair colour. The populous counties, Forfar, Fife, Stirling and Dumbarton, and the city of Edinburgh are fairly representative of the general population. The counties which diverge largely in hair colour from the general population, and have therefore non-representative populations, are Ross, Cromarty, Inverness and Argyll, the divergency being common to both the boy and girl populations. The divergency in the case of Argyll is due to excess of dark hair and jet black hair, and in the other cases to excesses of both fair and dark. The divergency in the north-east of Scotland is due to excess of red hair and fair hair. The seaboard on the west coast from Sutherland to Mull is highly divergent, due to significant excess of dark hair and jet black hair. In eye colour, the Southern and South-Eastern divisions are the most representative; the North-Western and South-Western the most divergent. Orkney, Shetland, Sutherland, Ross, Cromarty, Inverness, Elgin, Nairn and Forfar all diverge because of excess of blue eyes; in Sutherland and Forfar excess of dark eyes also contributes to the divergency. In the cities of Glasgow and Dundee, the divergency is due to excess of medium and dark eyes; in Aberdeen to medium; and in Leith to light and medium. The counties of Argyll, Dumbarton and Dumfries in the west diverge because of excess of light eyes; and Ayr because of blue and light. The isle of Lewis diverges because of excess of blue eyes and the isles of Jura and Islay because of excess of light. These islands contribute largely to the divergency of their respective counties, Inverness and Argyll.

IV. It has been proved (see II. and III.) that excesses in the various classes, or positive differences much in excess of the expected, occur all over the country,

frequently in contiguous areas, thus indicating a differentiation for each class from the general population. In measuring the degree of geographical separation or local segregation for each class, it has been proved that the blue-eyed and fair-haired classes have the greatest degree of local segregation. The segregation of these classes from the others is excessively great. Children belonging to these classes are congregated more in sparsely populated regions than in densely populated or moderately populated parts. The medium haired and medium eyed classes show the next greatest degree of local segregation. Children of these classes are congregated more in towns and in densely populated parts. The other classes all show a high degree of segregation except the red-haired class, which is almost uniformly distributed throughout the country. But for the regions of excess in the north-east of Scotland and in one or two other isolated and much smaller areas the distribution of this class would be practically uniform. This fact suggests that the occurrence of red hair (α) is independent of race, or (β) is one of the effects of blending of races, perhaps widely divergent races, or (γ) is an abnormal condition in hair colour and deserves the attention of the physiologist and pathologist. The statement of Tacitus as to the red-haired Caledonians points at least to the fact that red hair was a trait among the inhabitants of the north of Scotland in earlier times, and it is a striking circumstance that excess of this class is found in the region referred to by him.

V. It has been found that regions of excess of the dark-haired, jet black haired and blue-eyed classes are associated with regions of excess of the Gaelic speaking population. The measure of the association is given. This association was to be expected, seeing that these classes occur in excess in western counties, where the population is bilingual and where Gaelic is the mother tongue of a large proportion of the inhabitants. A typical Scoto-Kelt is therefore blue-eyed and dark-haired, but the light-eyed dark-haired type is also common in Argyll and its Isles. It will be seen later (XVI.) that there is a similar Irish type.

VI. It is proved that foreign immigrants tend to reside in the most densely populated areas in Scotland and in districts where families live in one or two rooms. The children of foreign immigrants have an effect,—scarcely an appreciable one,—on the population of Scotland as a whole, but in certain very densely populated parts they have a distinct effect. For example, it is shown that in certain divisions of Glasgow, Tradeston and Gorbals (see XVI.), the proportion of school children of foreign origin is so high as to change completely the nature of the distribution of hair colour and eye colour.

VII. It is proved that densely populated regions are positively correlated with excesses of the following classes: medium hair, medium eyes and dark eyes. The more densely populated a region is the greater will be the proportions of these classes in the population, and conversely, the more sparsely populated a region is, the smaller on an average will be the proportion of the classes just named.

VIII. It is well known that mortality is higher in more densely populated regions than others. It has been proved (see VII.) that certain classes are more characteristic of crowded areas than others. It is therefore to be expected that these classes would be positively correlated with the death rate. It is shown that an increase in the proportions of medium hair and dark eyes is associated with an increase in the death rate. This does not necessarily mean that persons belonging to these classes are less virile but simply that a large proportion of them live under conditions which are productive of a higher mortality. A direct investigation to determine whether any colour class is associated positively with a high death rate is desirable.

IX. It is shown that neither the Highland, Irish, English nor foreign elements in the population account for the high proportion of medium hair found in all densely populated regions. These elements however (excepting the English) where present, tend to increase the proportion of dark and jet black hair.

X. It is proved that the number of births per family is greater on an average in densely populated parts, and, as a consequence, that the number of births per family is greater where there are large proportions of medium hair and medium eyes. The lower classes are found in the denser centres. Thus it is likely that the medium haired, medium eyed lower classes are on an average more fertile than the remaining population. Here again a direct investigation is desirable.

XI. The main cause of the large excess of medium hair in densely populated parts probably arises from the blending of colour in the offspring of fair-haired and dark-haired persons: it is pointed out that blended inheritance exists in hair colour and what is wanted is a measure of its intensity. In densely populated areas, greater opportunities for intermixture of races occur, and it is shown (II. and III.) that in the large sparsely populated districts fair hair and dark hair, indicative of at least two different types, occur in excess, while in the urban regions these excesses mainly disappear and excess of medium hair appears.

XII. The excess of dark eyes in urban areas does not appear to be explainable in the same way. It has been suggested that exclusive inheritance in eye colour may be one of the causes of the excess in these areas. In the offspring of dark-eyed and blue-eyed parents it is possible that reversions may occur, maintaining the dark-eyed type.

XIII. The extent of the association of the colour classes geographically has been determined. One of the main results shows that as a rule medium hair is associated geographically with no other hair colour and goes to confirm the theory that medium hair is a blend. Thus it is to be expected that the proportion of this class will increase, tending to make the hair colour of the Scottish people more and more uniform. Excess of red hair is found as a rule only in regions where the proportion of dark hair is well below the average; a slight excess of fair is associated with excess of red. There is no positive association geographically of

any class with light eyes. Excess of blue eyes occurs alone, but excesses of dark eyes and medium eyes as a rule occur together.

XIV. It has already been shown elsewhere by the author that where there is an excess of light eyes in the population the number of cases of insanity is above the average and *vice versa*. It is now shown here that a greater number of cases of imbecility, blindness and deafness occurs in regions where blue eyes, dark and jet black hair are in excess. It has been already pointed out (see V.) that these classes are associated with the Gaelic speaking population. A direct determination of the relationship shows that significantly greater numbers of cases of these defects occur in Gaelic speaking regions than throughout the rest of Scotland. This is most probably due to the greater rate of emigration of the fitter portion from, and the relative absence of immigration to, the Highlands.

XV. The degree of resemblance between the boy and girl populations has been determined. It is found that positive and negative differences in the boy population are mainly associated with positive and negative differences in the girl population in the same regions. The resemblance is least in the red and dark-haired classes and greatest among the medium-haired and blue-eyed classes. The resemblance is closer in eye colour than in hair colour.

XVI. Glasgow so greatly diverges from the general population in hair colour and eye colour that it has been made the subject of a special investigation. The various municipalities constituting Greater Glasgow, as well as its environs, have been included in the investigation. It is shown that the Highland, Irish, foreign elements all contribute to increase the proportion of the dark-haired classes. Tradeston and Gorbals have greater proportions of dark hair, jet black hair and dark eyes, mainly due to the large foreign element present in these populous divisions. The detailed analysis shows that the immigrants are of Russian origin and this is confirmed by direct enquiry. More than 500 Jewish children attend school in these divisions. Dark hair, jet black hair, dark eyes are the leading classes in this population. The Highland and Irish elements are found all over the city. It is shown that the Irish resemble to a great extent in colour characters the Highland population. Both contribute very largely to the excess of dark hair. Medium hair is in excess all over the city, as expected, since this class is associated with density and since Glasgow contains a greater number of persons per square mile than any other part of Scotland. The high proportions of these classes (dark and medium) cause a corresponding defect in the proportion of fair hair in Glasgow. Only in one or two divisions, St Rollox, Dennistoun, and the Paisley district, does the proportion of fair hair approach the average for Scotland. In all the other divisions fair hair and blue eyes are distinctly below the average. It cannot be said from the results of this survey whether fair-haired and blue-eyed children are less fit for town life than the other classes, but the defect in fair hair at least is quite explainable on the ground that the proportion is disturbed (α) by a darker Scoto-Keltic or Highland element, (β) by a darker Irish element, (γ) by a darker foreign element and (δ) by the effects of blending of

fair and dark producing the various shades of brown classed as medium. All these contribute to the result and, taken together as a whole, are sufficient to cause the defect in the proportion of fair hair. *Entia non sunt multiplicanda.* It is probable that the country north-east and contiguous to Glasgow may contribute to the excess of dark eyes, but it is also probable, since the lower classes are more fertile, since dark eyes are associated with density, and since it has been shown elsewhere that dark eyes are associated with greater fertility, that greater fertility may contribute to produce the excess found in Glasgow.

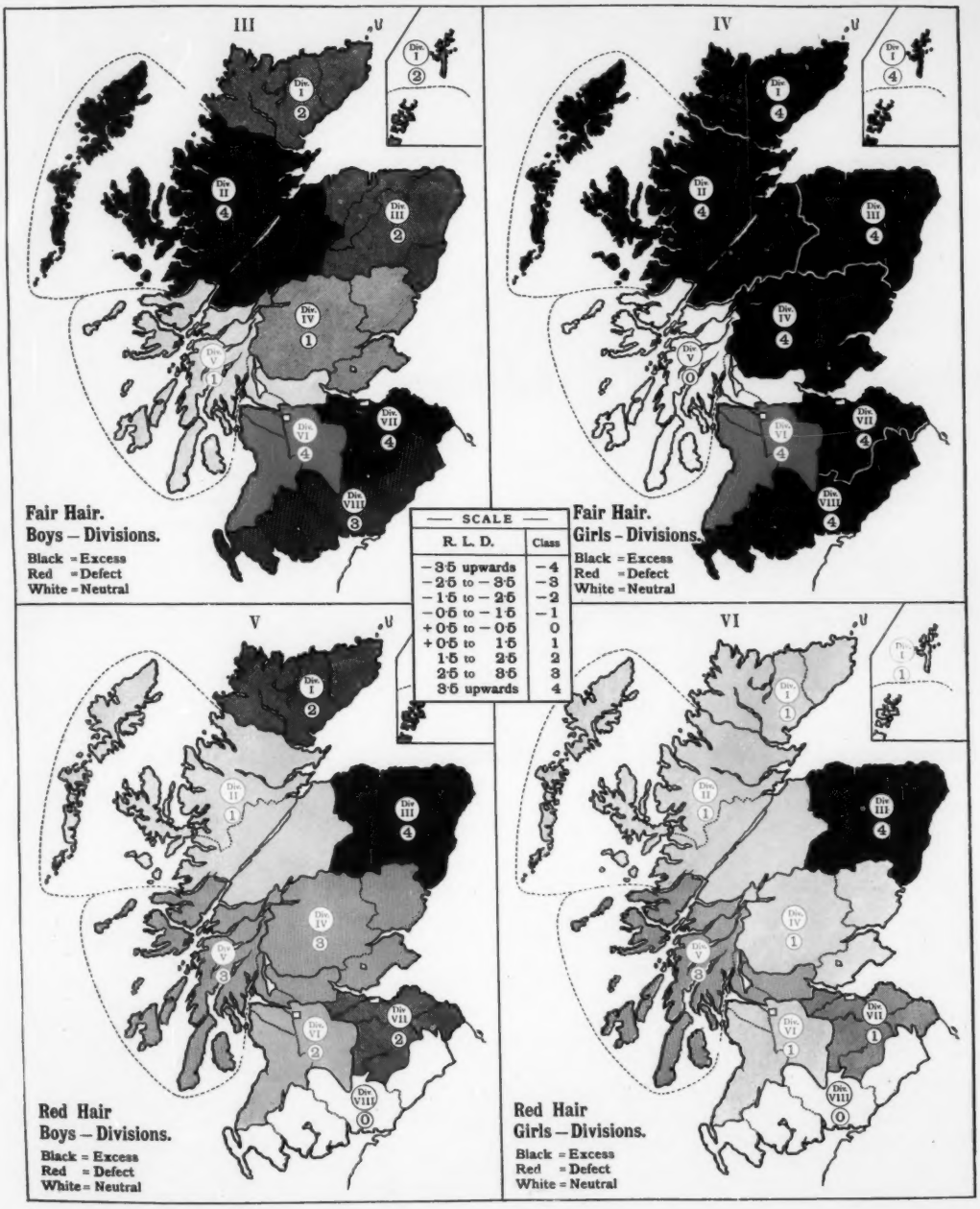
XVII. The population of East Aberdeenshire which was surveyed in 1896 has possibly become slightly darker in hair colour and lighter in eye colour in the eight years' interval. The change does not appear to have taken place in the rural districts but is more likely to have taken place in the two towns, Peterhead and Fraserburgh.

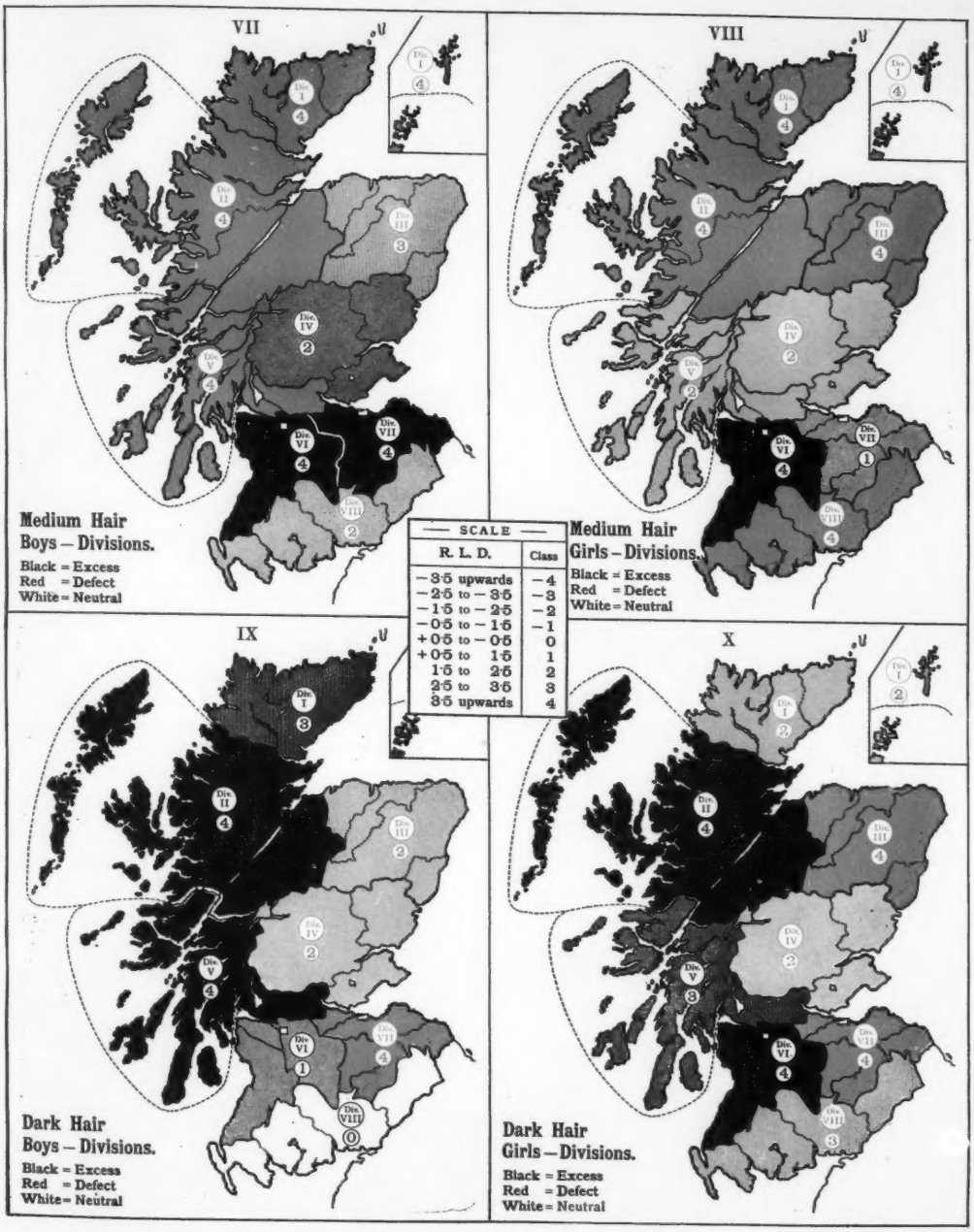
XVIII. The regions of excess and defect in hair colour and eye colour as found in surveying the Scottish insane correspond in many cases to similar regions as found by this survey. In others they do not agree. This arises mainly from (α) the fact that the insane are a somewhat selected population, (β) the fact that they are adults and not therefore directly comparable and (γ) the fact that the numbers are small compared with the numbers in this survey.

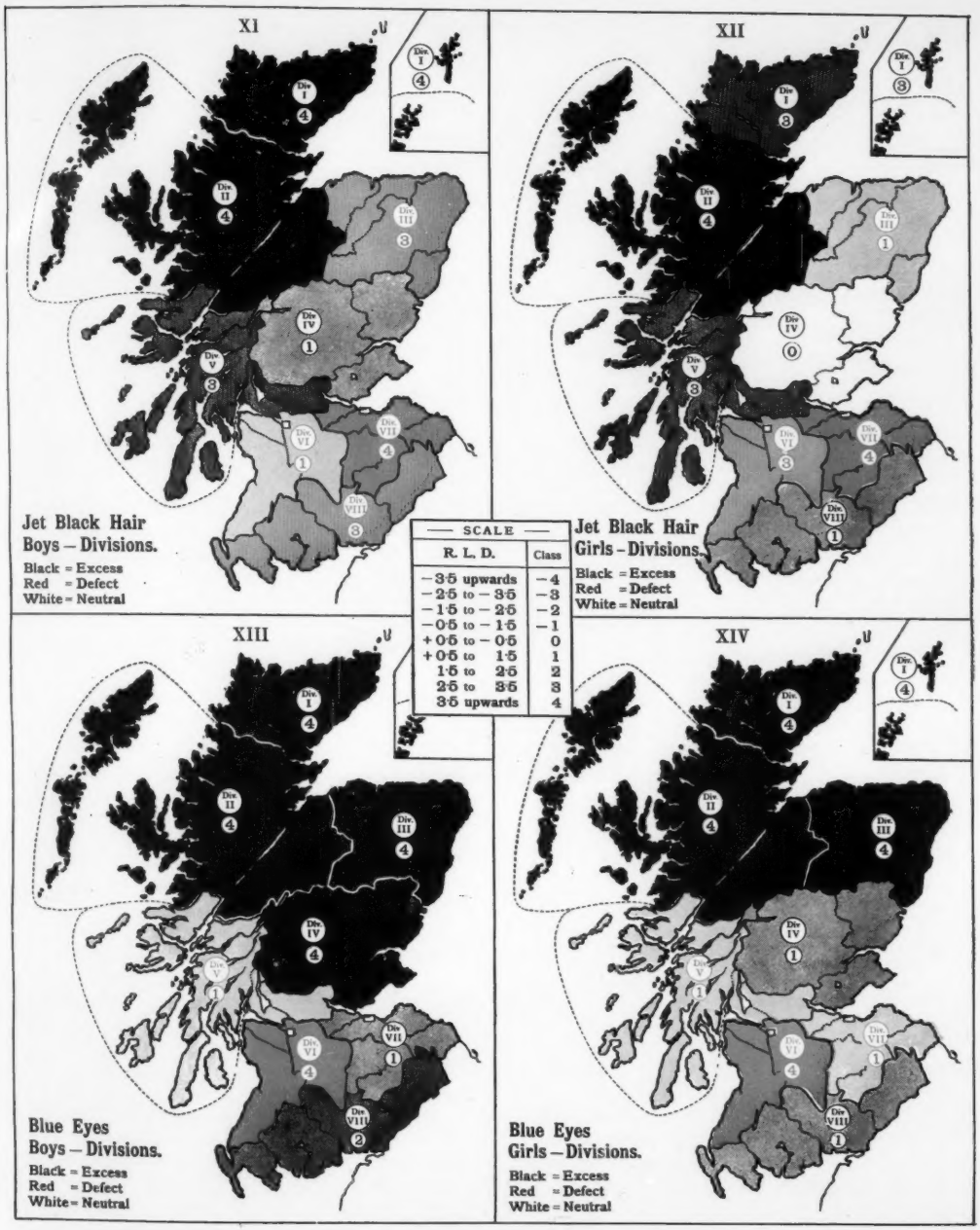
XIX. Several of Dr Beddoe's results have received confirmation, but the remarks on the Scottish insane (see XVIII. above) apply to his observations. His results are not directly comparable.

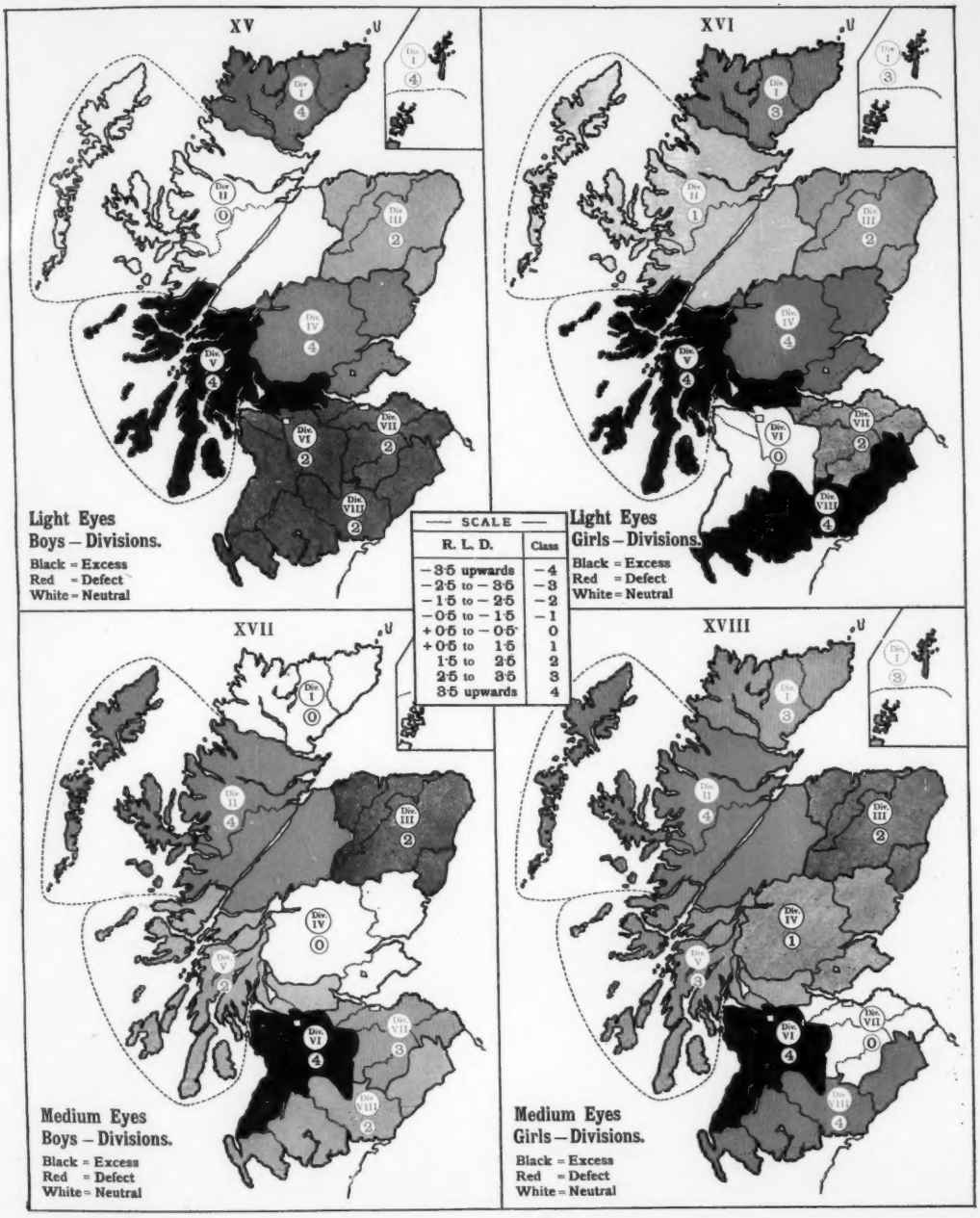
XX. The degree of association between hair colour and eye colour found from the results of this survey corresponds very closely to the values already found from other British and from foreign data.

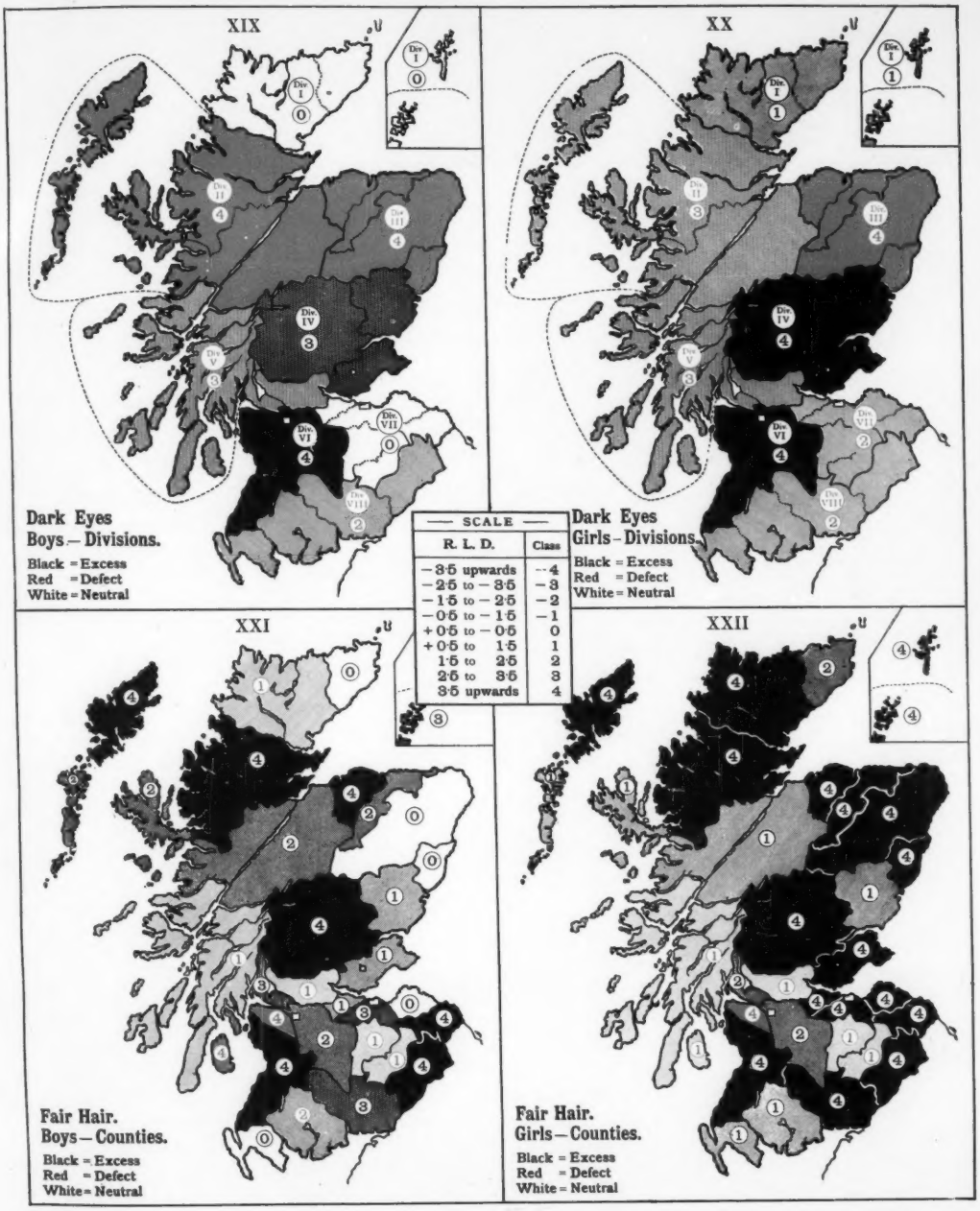
XXI. The results of this survey point to the conclusion that there are at least five types in Scotland. (α) One whose colour characters are dark hair and dark eyes; (β) dark hair and blue or light eyes; (γ) fair hair and blue eyes; (δ) a fourth type probably a product of two or more of the foregoing possessing medium hair (and perhaps dark hair) and medium eyes; (ϵ) a fifth type, possessing red hair associated mainly with medium eyes, is also present in small proportions (about 5 per cent.) and is also probably a product of two or more of the other types. These may be named respectively (α) the Dark European type (examples of subtypes: (1) Mediterranean, (2) Danish); (β) the Scoto-Keltic type; (γ) the Scandinavian or Germanic type; (δ) the Scottish type; and (ϵ) the Caledonian type.

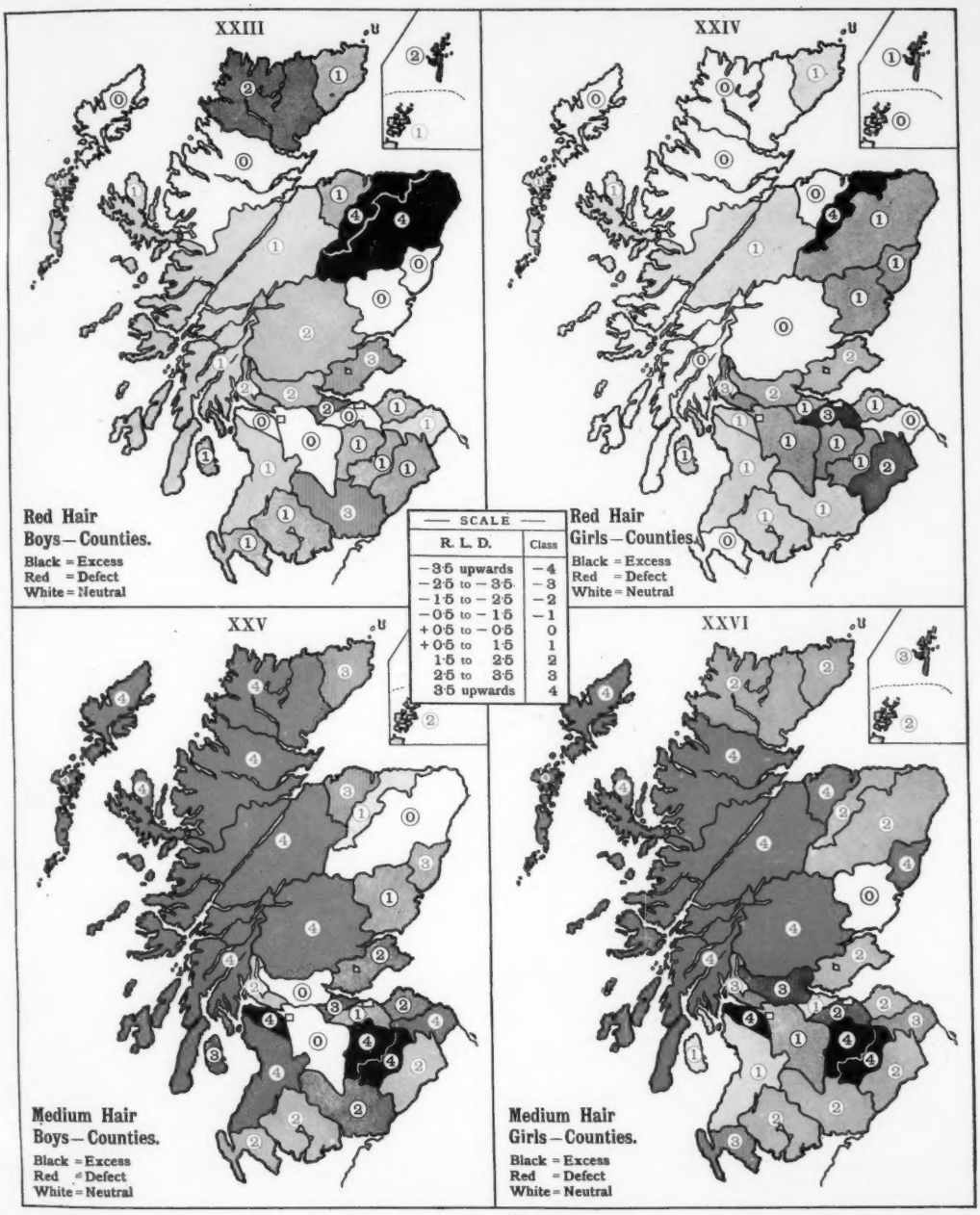

III
Div I 2
Div II 4
Div III 2
Div IV 1
Div V 1
Div VI 4
Div VII 4
Div VIII 3
Fair Hair.
Boys – Divisions.
Black = Excess
Red = Defect
White = Neutral
IV
Div I 4
Div II 4
Div III 4
Div IV 4
Div V 0
Div VI 4
Div VII 4
Div VIII 4
Fair Hair.
Girls – Divisions.
Black = Excess
Red = Defect
White = Neutral
SCALE
R. L. D. | Class
−3·5 upwards | −4
−2·5 to −3·5 | −3
−1·5 to −2·5 | −2
−0·5 to −1·5 | −1
+0·5 to −0·5 | 0
+0·5 to 1·5 | 1
1·5 to 2·5 | 2
2·5 to 3·5 | 3
3·5 upwards | 4
V
Div I 2
Div II 1
Div III 4
Div IV 3
Div V 3
Div VI 2
Div VII 2
Div VIII 0
Red Hair
Boys – Divisions.
Black = Excess
Red = Defect
White = Neutral
VI
Div I 1
Div II 1
Div III 4
Div IV 1
Div V 3
Div VI 1
Div VII 1
Div VIII 0
Red Hair
Girls – Divisions.
Black = Excess
Red = Defect
White = Neutral

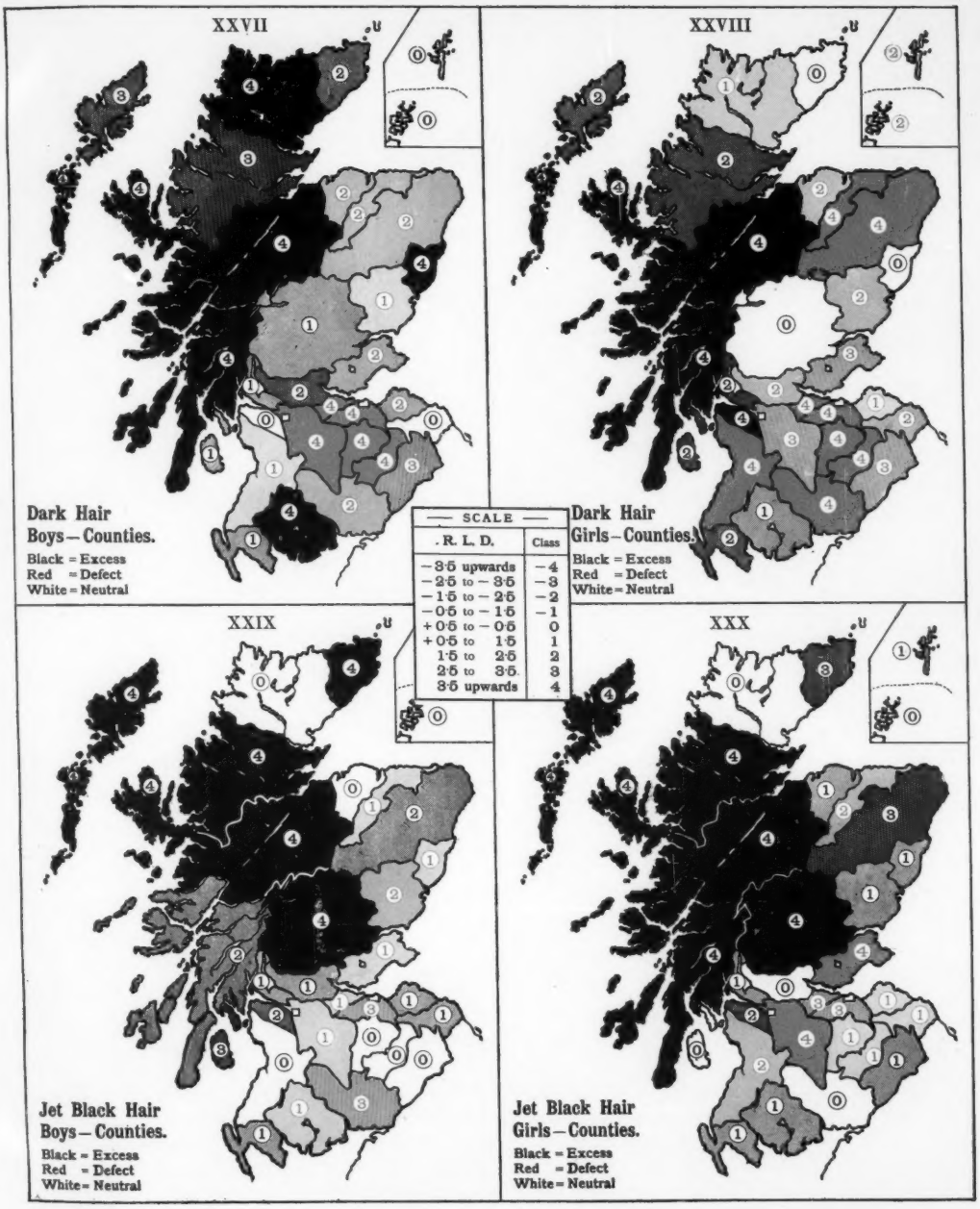

VII
Medium Hair
Boys – Divisions.
Black = Excess
Red = Defect
White = Neutral
VIII
Medium Hair
Girls – Divisions.
Black = Excess
Red = Defect
White = Neutral
SCALE
R. L. D. | Class
−3·5 upwards | −4
−2·5 to −3·5 | −3
−1·5 to −2·5 | −2
−0·5 to −1·5 | −1
+0·5 to −0·5 | 0
+0·5 to 1·5 | 1
1·5 to 2·5 | 2
2·5 to 3·5 | 3
3·5 upwards | 4
IX
Dark Hair
Boys – Divisions.
Black = Excess
Red = Defect
White = Neutral
X
Dark Hair
Girls – Divisions.
Black = Excess
Red = Defect
White = Neutral

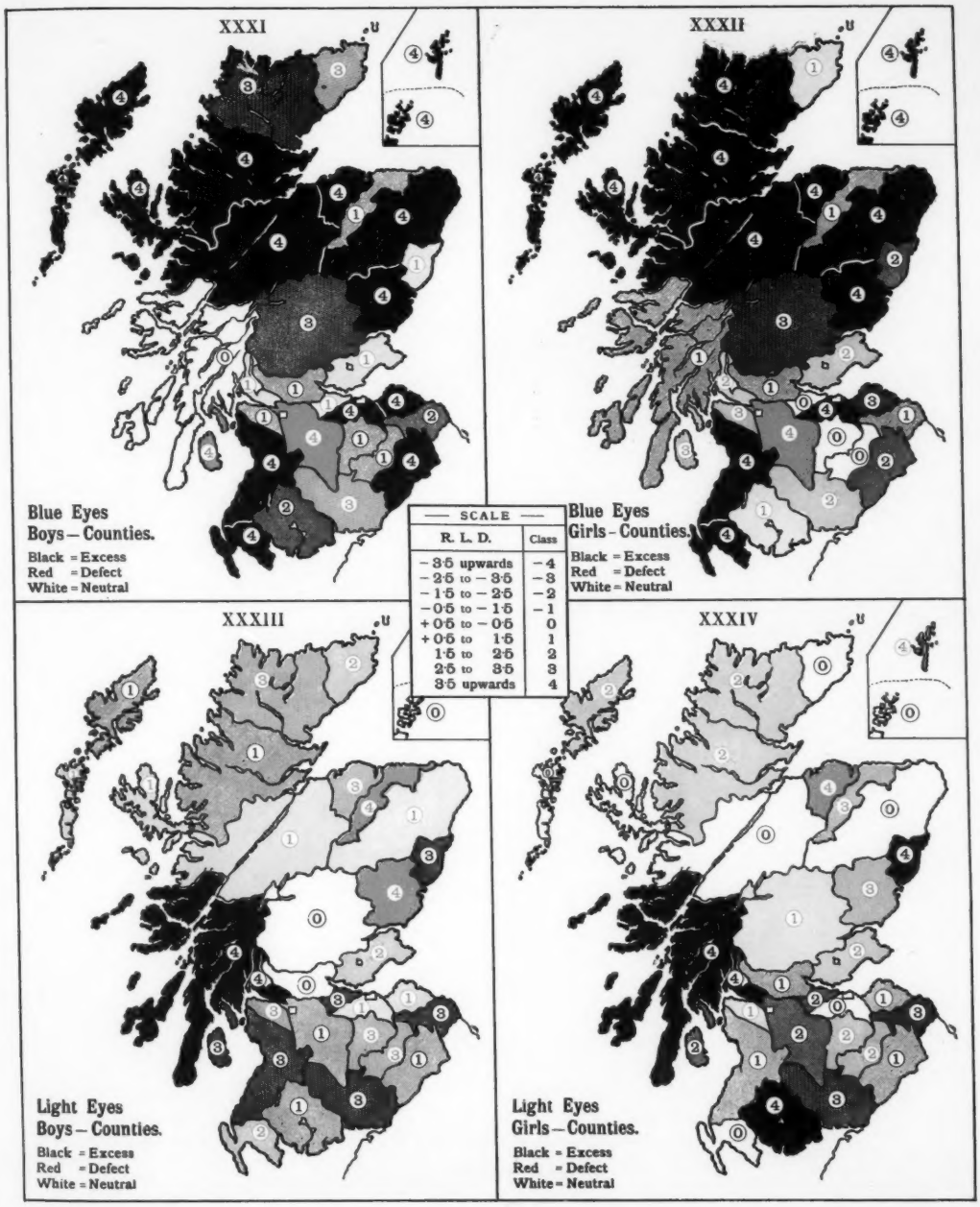

XI
Div I 4
Div II 4
Div III 3
Div IV 1
Div V 3
Div VI 1
Div VII 4
Div VIII 3
Jet Black Hair
Boys – Divisions.
Black = Excess
Red = Defect
White = Neutral
XII
Div I 3
Div II 4
Div III 1
Div IV 0
Div V 3
Div VI 3
Div VII 4
Div VIII 1
Jet Black Hair
Girls – Divisions.
Black = Excess
Red = Defect
White = Neutral
SCALE
R. L. D. | Class
−3·5 upwards | −4
−2·5 to −3·5 | −3
−1·5 to −2·5 | −2
−0·5 to −1·5 | −1
+0·5 to −0·5 | 0
+0·5 to 1·5 | 1
1·5 to 2·5 | 2
2·5 to 3·5 | 3
3·5 upwards | 4
XIII
Div I 4
Div II 4
Div III 4
Div IV 4
Div V 1
Div VI 4
Div VII 1
Div VIII 2
Blue Eyes
Boys – Divisions.
Black = Excess
Red = Defect
White = Neutral
XIV
Div I 4
Div II 4
Div III 4
Div IV 1
Div V 1
Div VI 4
Div VII 1
Div VIII 1
Blue Eyes
Girls – Divisions.
Black = Excess
Red = Defect
White = Neutral

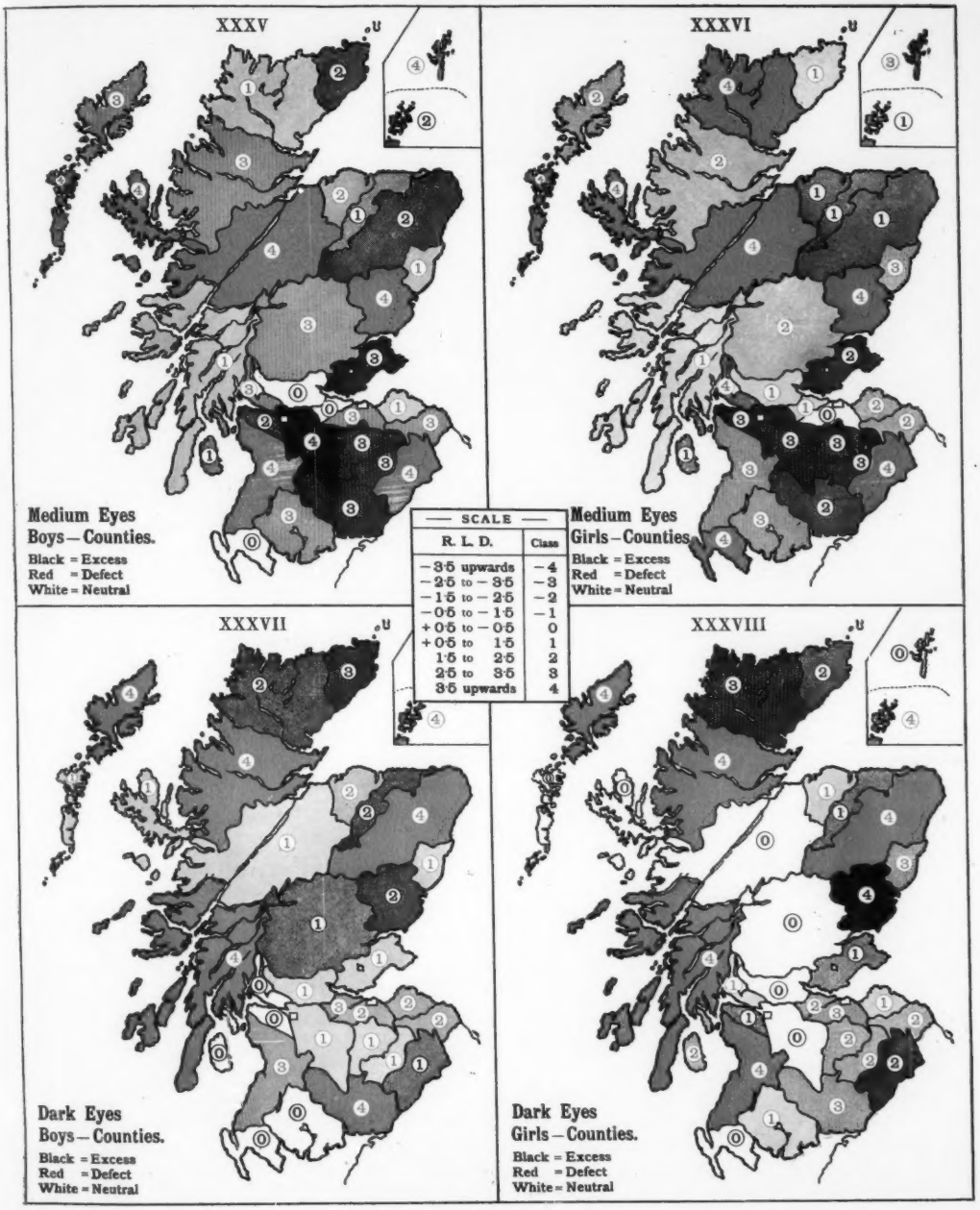

XV
Div I 4
Div II 0
Div III 2
Div IV 4
Div V 4
Div VI 2
Div VII 2
Div VIII 2
Light Eyes
Boys — Divisions.
Black = Excess
Red = Defect
White = Neutral
XVI
Div I 3
Div II 1
Div III 2
Div IV 4
Div V 4
Div VI 0
Div VII 2
Div VIII 4
Light Eyes
Girls — Divisions.
Black = Excess
Red = Defect
White = Neutral
SCALE
R. L. D. | Class
−3·5 upwards | −4
−2·5 to −3·5 | −3
−1·5 to −2·5 | −2
−0·5 to −1·5 | −1
+0·5 to −0·5 | 0
+0·5 to 1·5 | 1
1·5 to 2·5 | 2
2·5 to 3·5 | 3
3·5 upwards | 4
XVII
Div I 0
Div II 4
Div III 2
Div IV 0
Div V 2
Div VI 4
Div VII 3
Div VIII 2
Medium Eyes
Boys — Divisions.
Black = Excess
Red = Defect
White = Neutral
XVIII
Div I 3
Div II 4
Div III 2
Div IV 1
Div V 3
Div VI 4
Div VII 0
Div VIII 4
Medium Eyes
Girls — Divisions.
Black = Excess
Red = Defect
White = Neutral

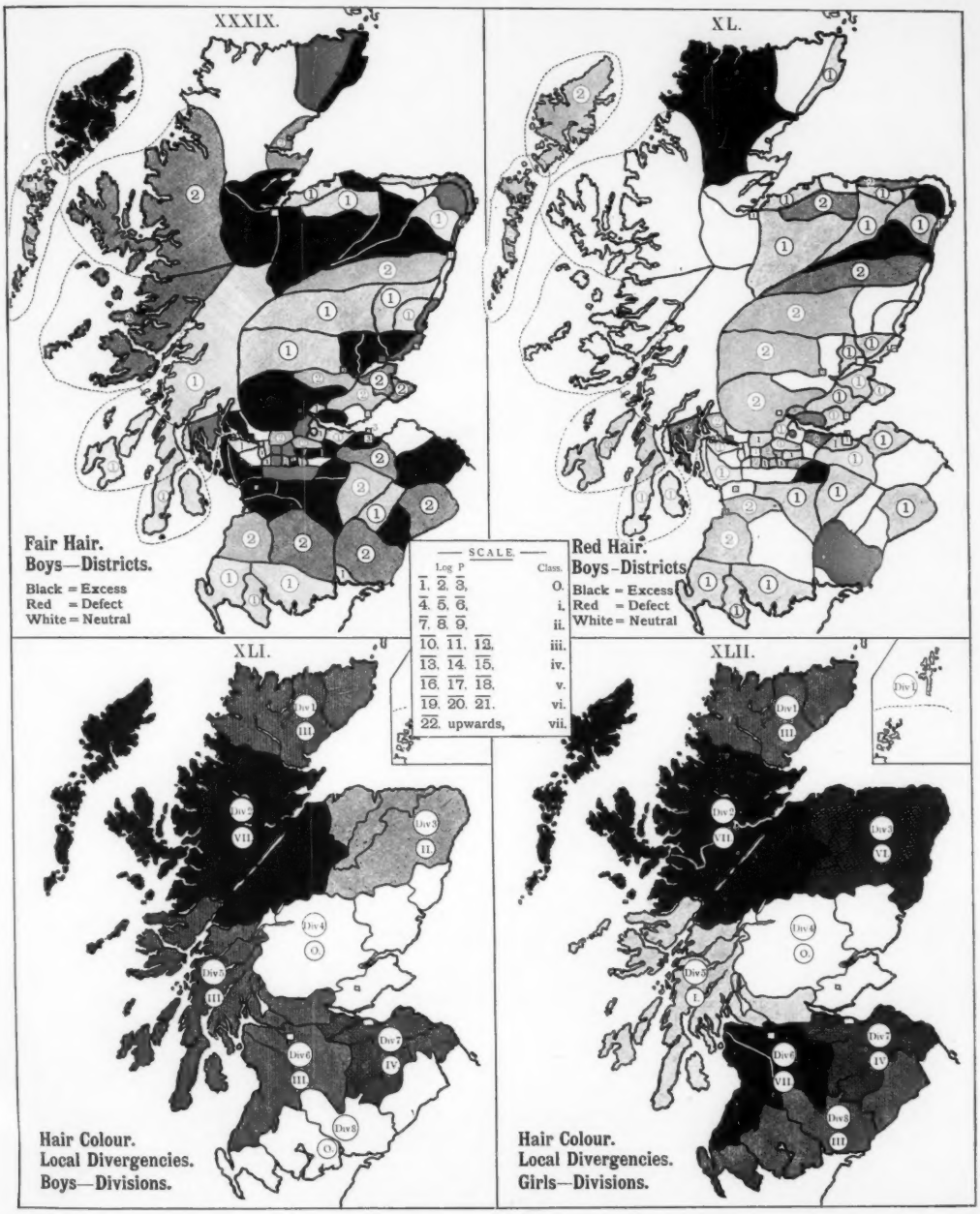

XIX
Dark Eyes
Boys.—Divisions.
Black = Excess
Red = Defect
White = Neutral
XX
Dark Eyes
Girls—Divisions.
Black = Excess
Red = Defect
White = Neutral
SCALE
R. L. D. | Class
−3·5 upwards | −4
−2·5 to −3·5 | −3
−1·5 to −2·5 | −2
−0·5 to −1·5 | −1
+0·5 to −0·5 | 0
+0·5 to 1·5 | 1
1·5 to 2·5 | 2
2·5 to 3·5 | 3
3·5 upwards | 4
XXI
Fair Hair.
Boys—Counties.
Black = Excess
Red = Defect
White = Neutral
XXII
Fair Hair.
Girls—Counties.
Black = Excess
Red = Defect
White = Neutral

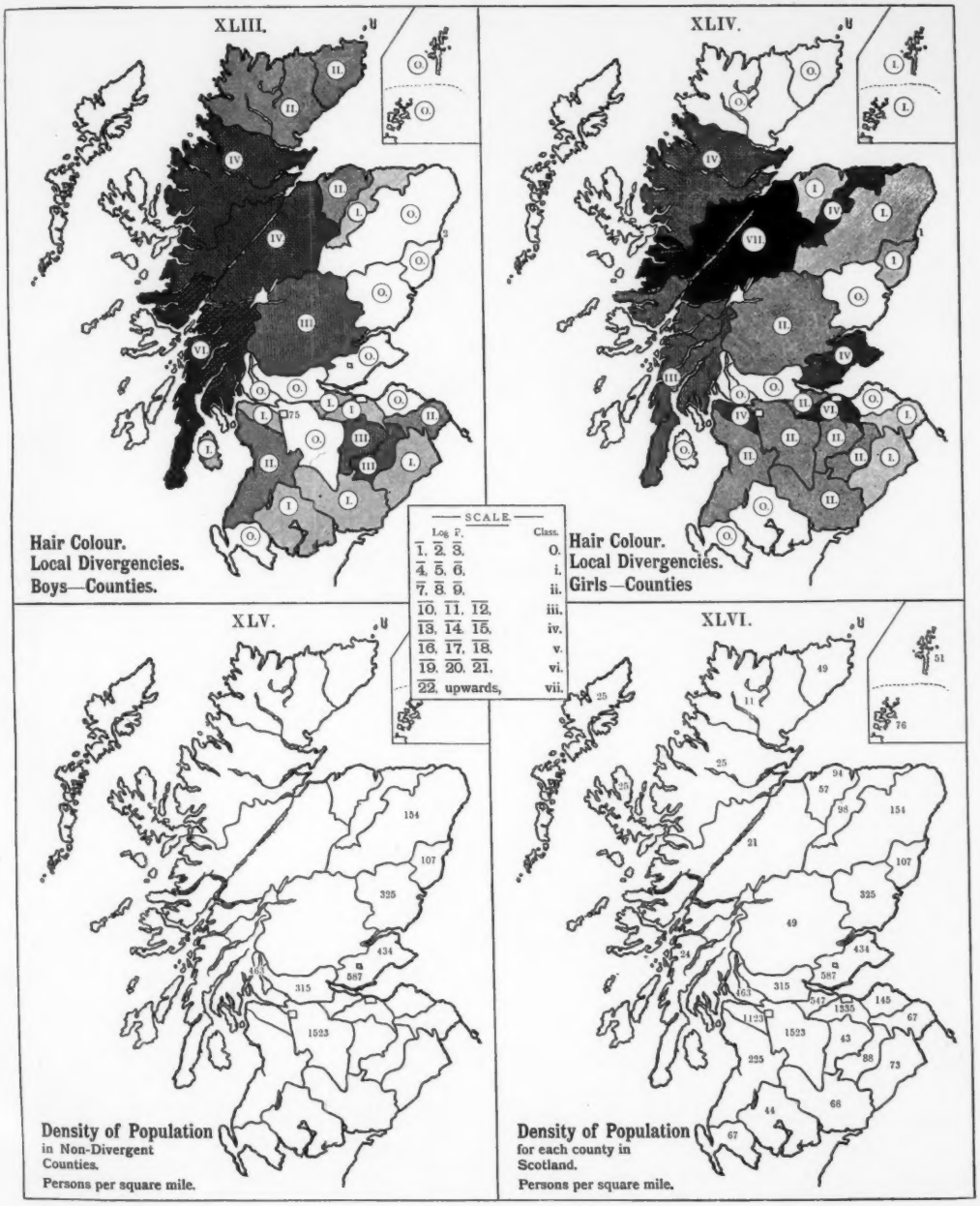

XXIII
Red Hair
Boys—Counties.
Black = Excess
Red = Defect
White = Neutral
XXIV
Red Hair
Girls—Counties.
Black = Excess
Red = Defect
White = Neutral
SCALE
R. L. D. | Class
−3·5 upwards | −4
−2·5 to −3·5 | −3
−1·5 to −2·5 | −2
−0·5 to −1·5 | −1
+0·5 to −0·5 | 0
+0·5 to 1·5 | 1
1·5 to 2·5 | 2
2·5 to 3·5 | 3
3·5 upwards | 4
XXV
Medium Hair
Boys—Counties.
Black = Excess
Red = Defect
White = Neutral
XXVI
Medium Hair
Girls—Counties.
Black = Excess
Red = Defect
White = Neutral


XXVII
Dark Hair
Boys—Counties.
Black = Excess
Red = Defect
White = Neutral
XXVIII
Dark Hair
Girls—Counties.
Black = Excess
Red = Defect
White = Neutral
SCALE
R. L. D. | Class
−3·5 upwards | −4
−2·5 to −3·5 | −3
−1·5 to −2·5 | −2
−0·5 to −1·5 | −1
+0·5 to −0·5 | 0
+0·5 to 1·5 | 1
1·5 to 2·5 | 2
2·5 to 3·5 | 3
3·5 upwards | 4
XXIX
Jet Black Hair
Boys—Counties.
Black = Excess
Red = Defect
White = Neutral
XXX
Jet Black Hair
Girls—Counties.
Black = Excess
Red = Defect
White = Neutral

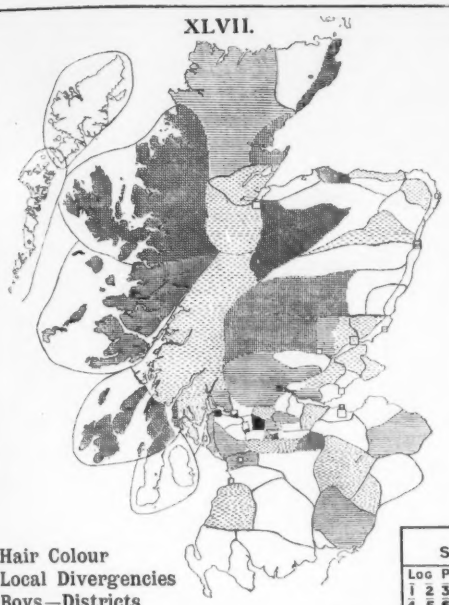

XXXI
U
Blue Eyes
Boys – Counties.
Black = Excess
Red = Defect
White = Neutral
XXXII
U
Blue Eyes
Girls – Counties.
Black = Excess
Red = Defect
White = Neutral
— SCALE —
R. L. D. | Class
– 3·5 upwards | – 4
– 2·5 to – 3·5 | – 3
– 1·5 to – 2·5 | – 2
– 0·5 to – 1·5 | – 1
+ 0·5 to – 0·5 | 0
+ 0·5 to 1·5 | 1
1·5 to 2·5 | 2
2·5 to 3·5 | 3
3·5 upwards | 4
XXXIII
U
Light Eyes
Boys – Counties.
Black = Excess
Red = Defect
White = Neutral
XXXIV
U
Light Eyes
Girls – Counties.
Black = Excess
Red = Defect
White = Neutral


XXXV
Medium Eyes
Boys — Counties.
Black = Excess
Red = Defect
White = Neutral
XXXVI
Medium Eyes
Girls — Counties.
Black = Excess
Red = Defect
White = Neutral
SCALE
R. L. D. | Class
−3·5 upwards | −4
−2·5 to −3·5 | −3
−1·5 to −2·5 | −2
−0·5 to −1·5 | −1
+0·5 to −0·5 | 0
+0·5 to 1·5 | 1
1·5 to 2·5 | 2
2·5 to 3·5 | 3
3·5 upwards | 4
XXXVII
Dark Eyes
Boys — Counties.
Black = Excess
Red = Defect
White = Neutral
XXXVIII
Dark Eyes
Girls — Counties.
Black = Excess
Red = Defect
White = Neutral


XXXIX.
Fair Hair.
Boys—Districts.
Black = Excess
Red = Defect
White = Neutral
XL.
Red Hair.
Boys–Districts
Black = Excess
Red = Defect
White = Neutral
SCALE.
Log P
Class.
1. 2. 3. O.
4. 5. 6. i.
7. 8. 9. ii.
10. 11. 12. iii.
13. 14. 15. iv.
16. 17. 18. v.
19. 20. 21. vi.
22. upwards, vii.
XLI.
Hair Colour.
Local Divergencies.
Boys—Divisions.
XLII.
Hair Colour.
Local Divergencies.
Girls—Divisions.


XLIII.
Hair Colour.
Local Divergencies.
Boys—Counties.
XLIV.
Hair Colour.
Local Divergencies.
Girls—Counties
SCALE.
Log F. Class.
1, 2, 3, 0.
4, 5, 6, i.
7, 8, 9, ii.
10, 11, 12, iii.
13, 14, 15, iv.
16, 17, 18, v.
19, 20, 21, vi.
22, upwards, vii.
XLV.
Density of Population
in Non-Divergent
Counties.
Persons per square mile.
XLVI.
Density of Population
for each county in
Scotland.
Persons per square mile.

XLVII.



Hair Colour
Local Divergencies
Boys—Districts

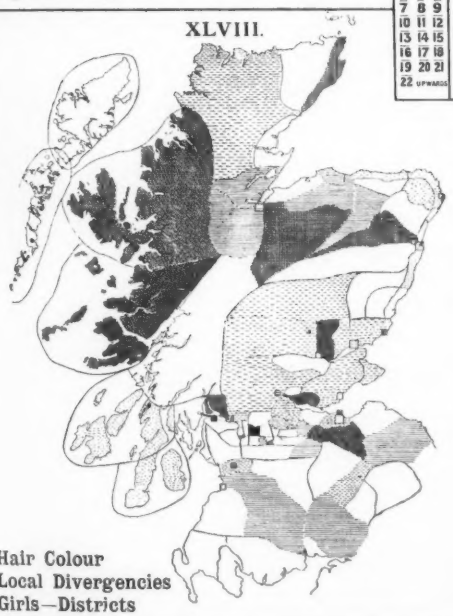
XLIX.

Eye Colour
Local Divergencies
Boys—Districts

SCALE

Log P			Class
1	2	3	0
4	5	6	I
7	8	9	II
10	11	12	III
13	14	15	IV
16	17	18	V
19	20	21	VI
22 upwards			VII

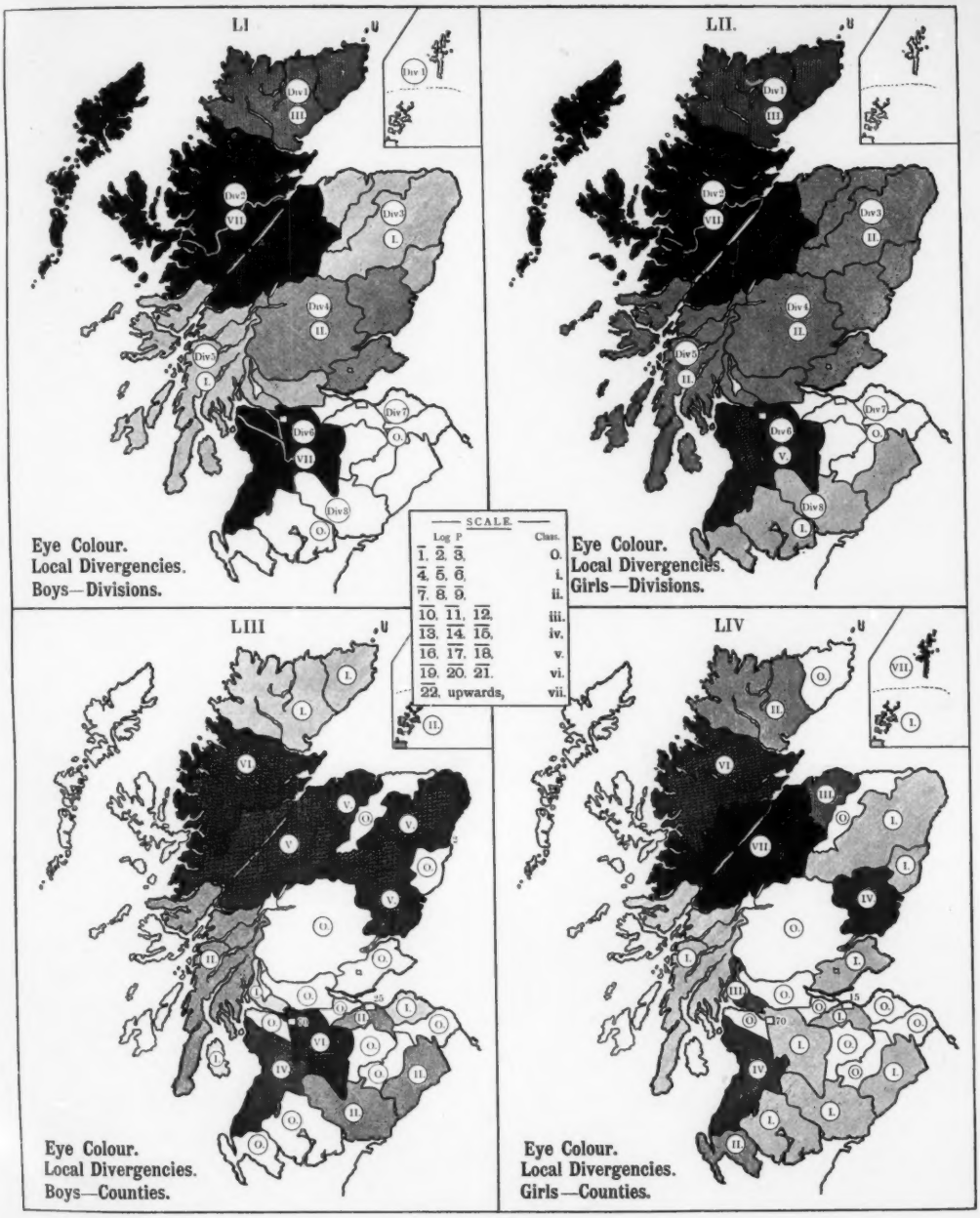
XLVIII.



Hair Colour
Local Divergencies
Girls—Districts

L.

Eye Colour
Local Divergencies
Girls—Districts


LI
Div1
III
Div2
VII
Div3
I
Div4
II
Div5
I
Div6
VII
Div7
O
Div8
O
Eye Colour.
Local Divergencies.
Boys—Divisions.
LII.
Div1
III
Div2
VII
Div3
II
Div4
II
Div5
II
Div6
V
Div7
O
Div8
I
Eye Colour.
Local Divergencies.
Girls—Divisions.
SCALE.
Log P
Class.
1, 2, 3, O.
4, 5, 6, i.
7, 8, 9, ii.
10, 11, 12, iii.
13, 14, 15, iv.
16, 17, 18, v.
19, 20, 21, vi.
22, upwards, vii.
LIII
Eye Colour.
Local Divergencies.
Boys—Counties.
LIV
Eye Colour.
Local Divergencies.
Girls—Counties.

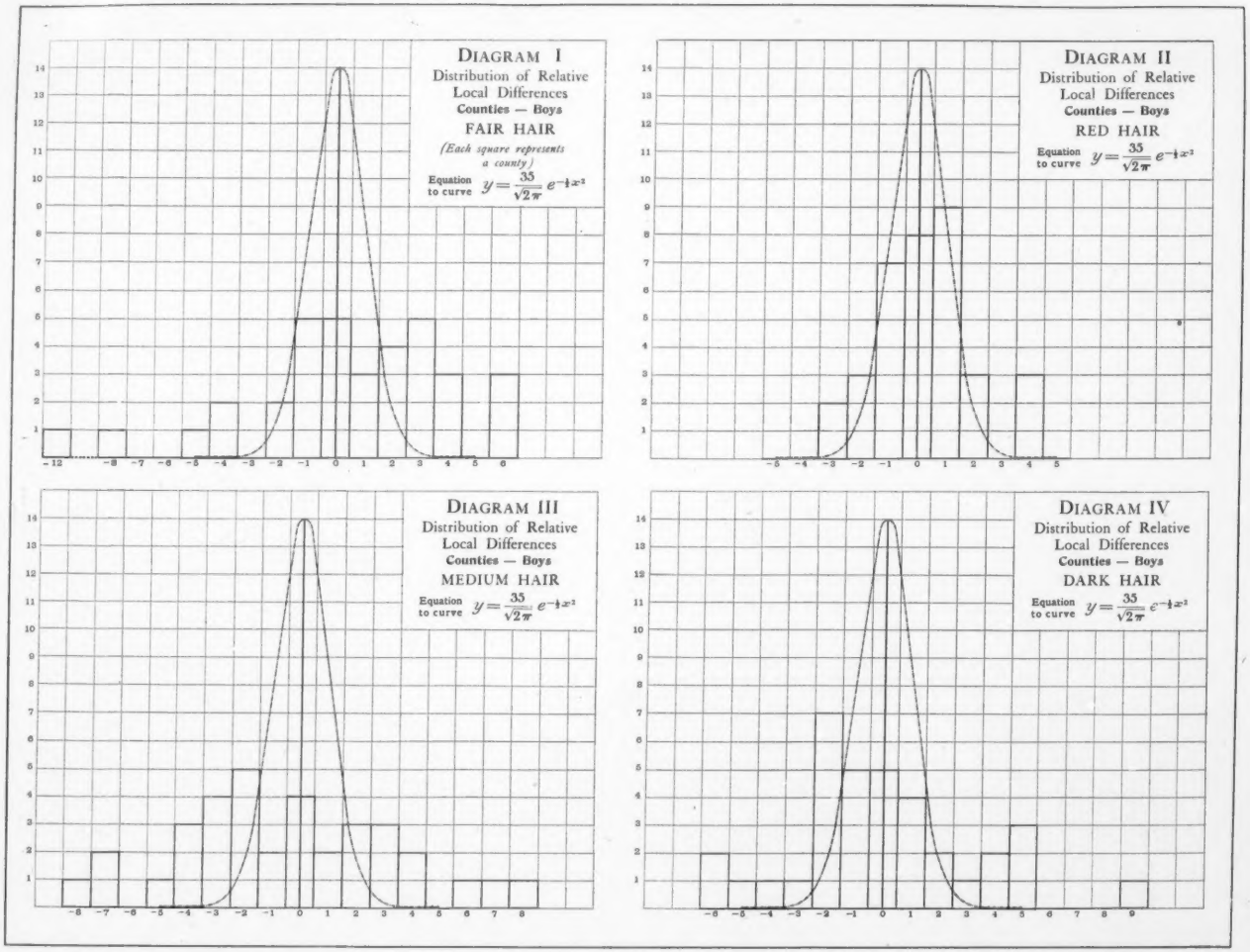


DIAGRAM I
Distribution of Relative Local Differences
Counties — Boys
FAIR HAIR
(Each square represents a county)
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$
DIAGRAM II
Distribution of Relative Local Differences
Counties — Boys
RED HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$
DIAGRAM III
Distribution of Relative Local Differences
Counties — Boys
MEDIUM HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$
DIAGRAM IV
Distribution of Relative Local Differences
Counties — Boys
DARK HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

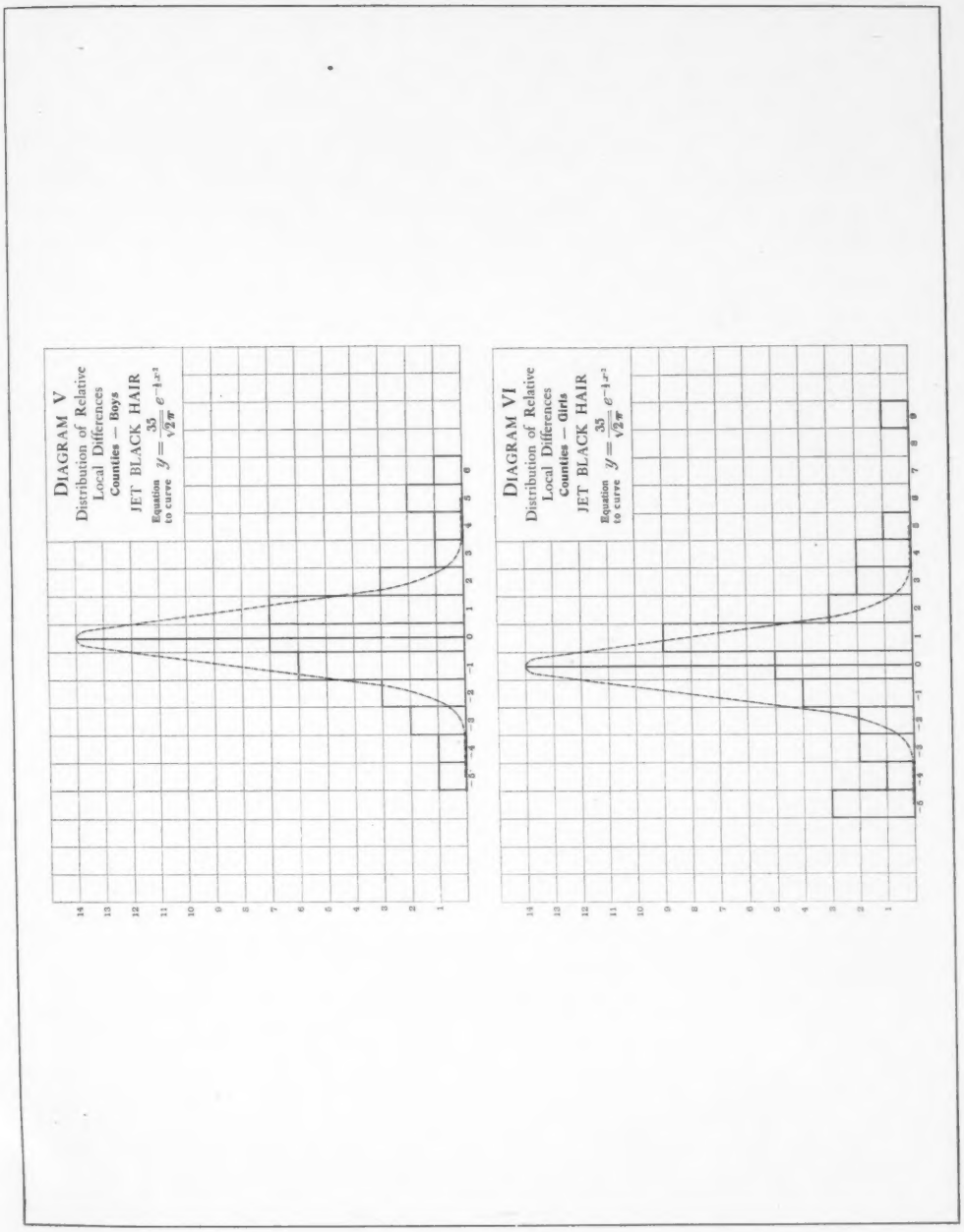


DIAGRAM V
Distribution of Relative Local Differences
Counties — Boys
JET BLACK HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$
DIAGRAM VI
Distribution of Relative Local Differences
Counties — Girls
JET BLACK HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

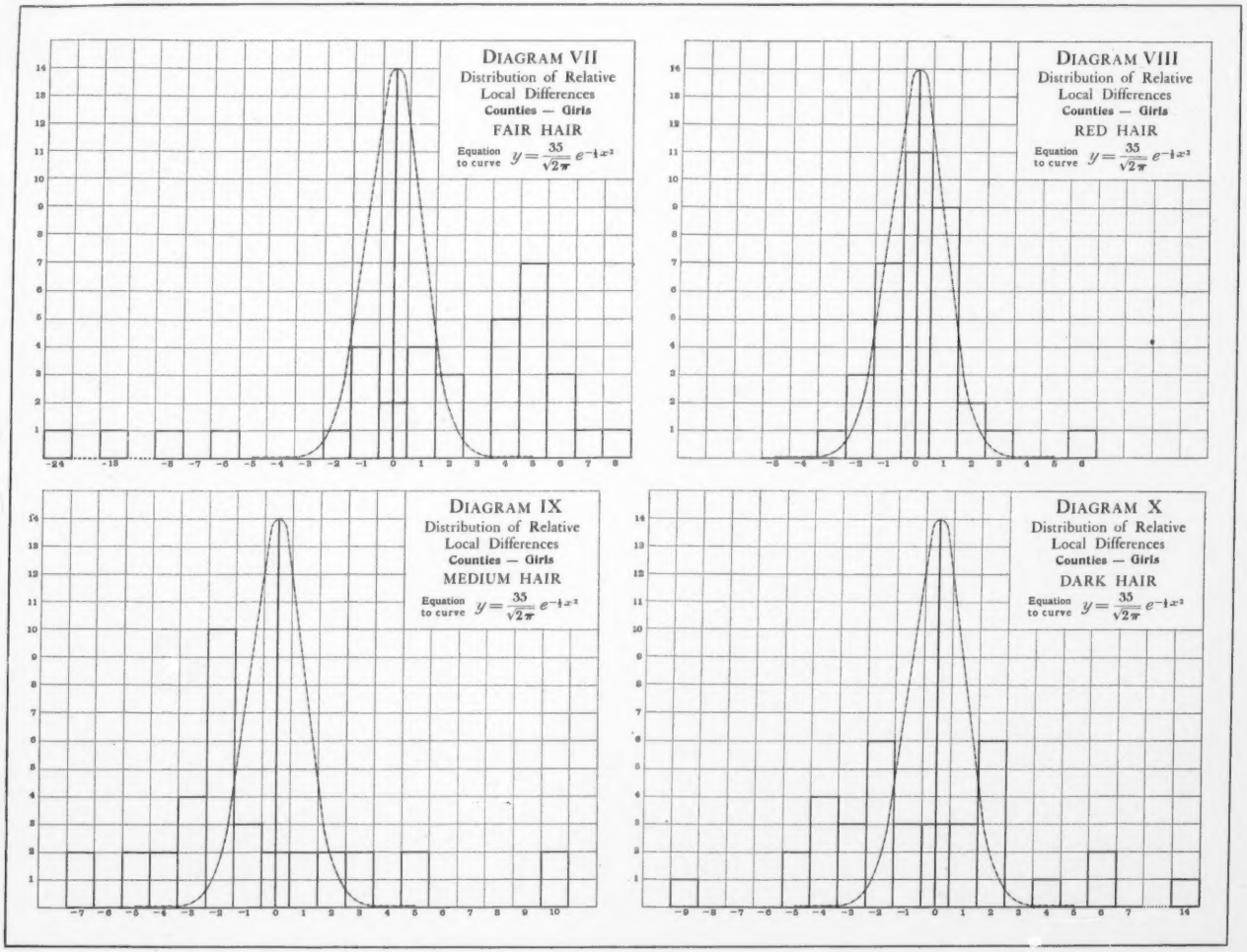


DIAGRAM VII
Distribution of Relative Local Differences
Counties — Girls
FAIR HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$
DIAGRAM VIII
Distribution of Relative Local Differences
Counties — Girls
RED HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$
DIAGRAM IX
Distribution of Relative Local Differences
Counties — Girls
MEDIUM HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$
DIAGRAM X
Distribution of Relative Local Differences
Counties — Girls
DARK HAIR
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

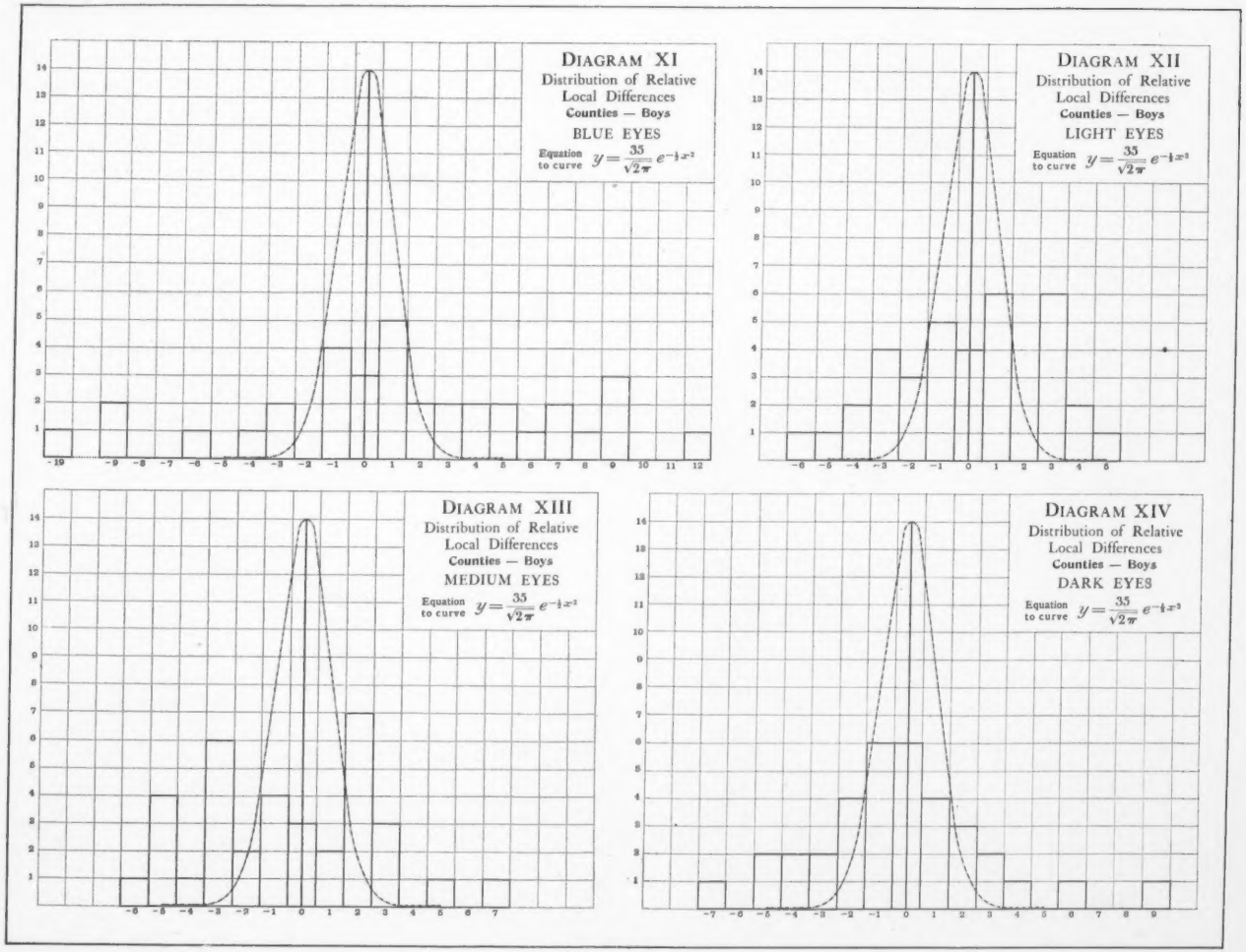


DIAGRAM XI
Distribution of Relative Local Differences
Counties — Boys
BLUE EYES
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$
DIAGRAM XII
Distribution of Relative Local Differences
Counties — Boys
LIGHT EYES
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$
DIAGRAM XIII
Distribution of Relative Local Differences
Counties — Boys
MEDIUM EYES
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$
DIAGRAM XIV
Distribution of Relative Local Differences
Counties — Boys
DARK EYES
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

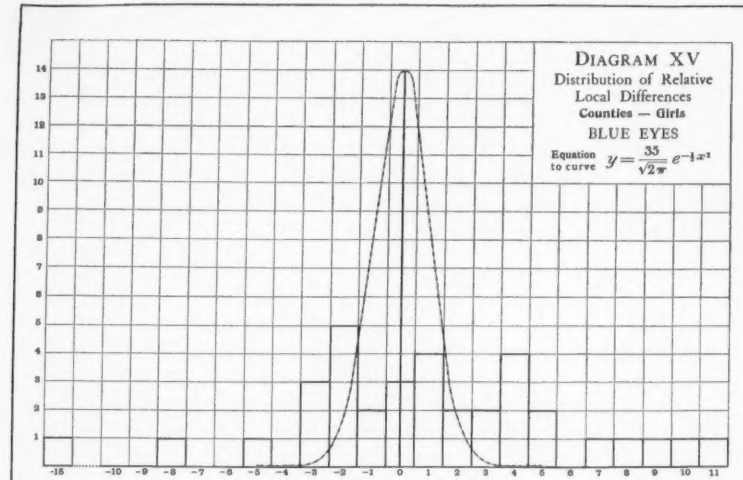


DIAGRAM XV
Distribution of Relative Local Differences
Counties — Girls
BLUE EYES
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

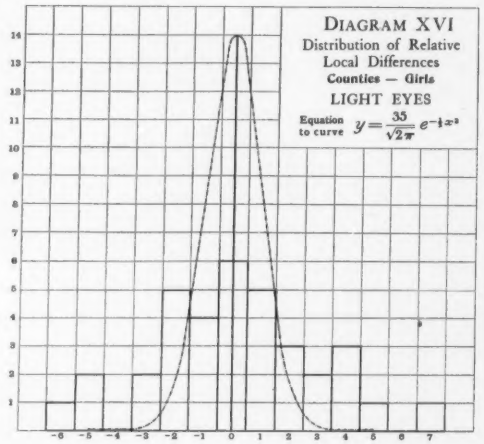


DIAGRAM XVI
Distribution of Relative Local Differences
Counties — Girls
LIGHT EYES
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

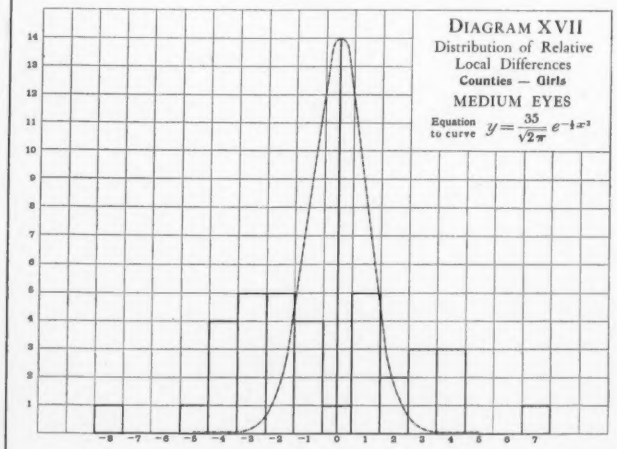


DIAGRAM XVII
Distribution of Relative Local Differences
Counties — Girls
MEDIUM EYES
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

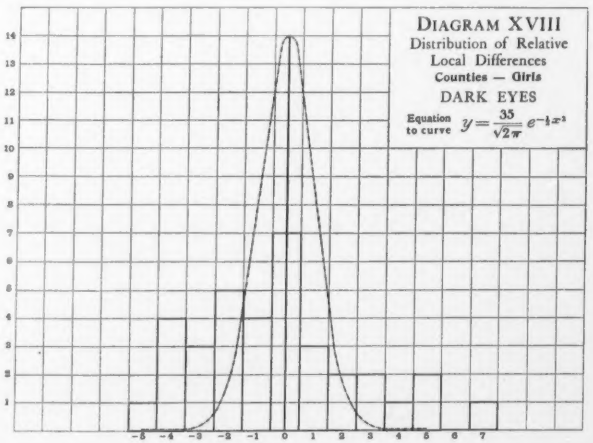
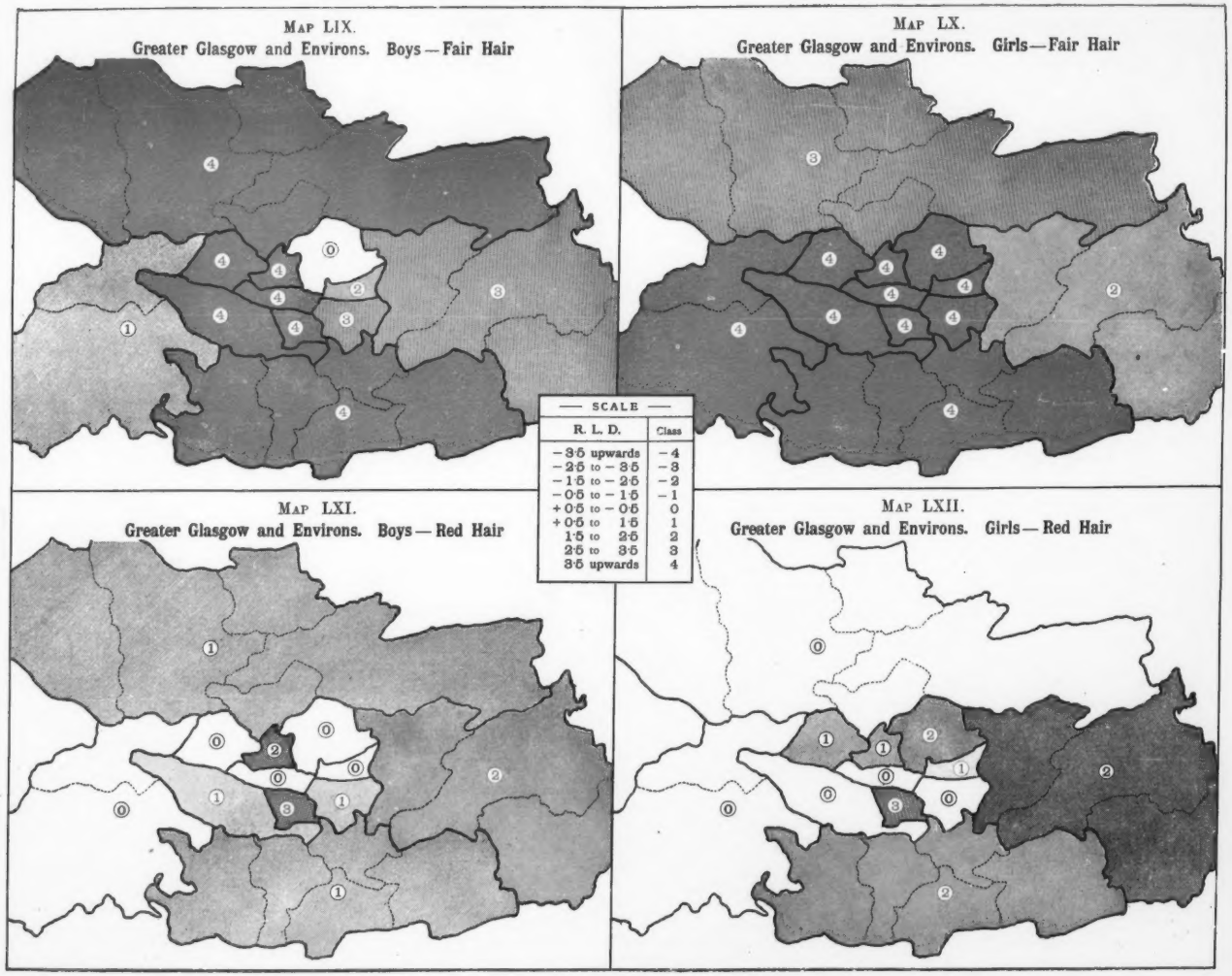


DIAGRAM XVIII
Distribution of Relative Local Differences
Counties — Girls
DARK EYES
Equation to curve $y = \frac{35}{\sqrt{2\pi}} e^{-\frac{1}{2}x^2}$

MAP LV.
Greater Glasgow and Environs. Boys—Divergency in Hair Colour.
MAP LVI.
Greater Glasgow and Environs. Girls—Divergency in Hair Colour.
SCALE
Log P
Class
1. 2. 3. 0.
4. 5. 6. i.
7. 8. 9. ii.
10. 11. 12. iii.
13. 14. 15. iv.
16. 17. 18. v
19. 20. 21 vi.
22. upwards, vii.
MAP LVII.
Greater Glasgow and Environs. Boys—Divergency in Eye Colour.
MAP LVIII.
Greater Glasgow and Environs. Girls—Divergency in Eye Colour.


MAP LIX.
Greater Glasgow and Environs. Boys—Fair Hair
MAP LX.
Greater Glasgow and Environs. Girls—Fair Hair
MAP LXI.
Greater Glasgow and Environs. Boys—Red Hair
MAP LXII.
Greater Glasgow and Environs. Girls—Red Hair
SCALE
R. L. D. | Class
−3·5 upwards | −4
−2·5 to −3·5 | −3
−1·5 to −2·5 | −2
−0·5 to −1·5 | −1
+0·5 to −0·5 | 0
+0·5 to 1·5 | 1
1·5 to 2·5 | 2
2·5 to 3·5 | 3
3·5 upwards | 4

Map LXIII.
Greater Glasgow and Environs. Boys—Medium Hair
Map LXIV.
Greater Glasgow and Environs. Girls—Medium Hair
Map LXV.
Greater Glasgow and Environs. Boys—Dark Hair
Map LXVI.
Greater Glasgow and Environs. Girls—Dark Hair
— SCALE —
R. L. D. | Class
−·35 upwards | −4
−·25 to −·35 | −3
−·15 to −·25 | −2
−·05 to −·15 | −1
+·05 to −·05 | 0
+·05 to ·15 | 1
·15 to ·25 | 2
·25 to ·35 | 3
·35 upwards | 4

Map LXVII.
Greater Glasgow and Environs. Boys—Jet Black Hair
Map LXVIII.
Greater Glasgow and Environs. Girls—Jet Black Hair
Map LXIX.
Greater Glasgow and Environs. Boys—Blue Eyes
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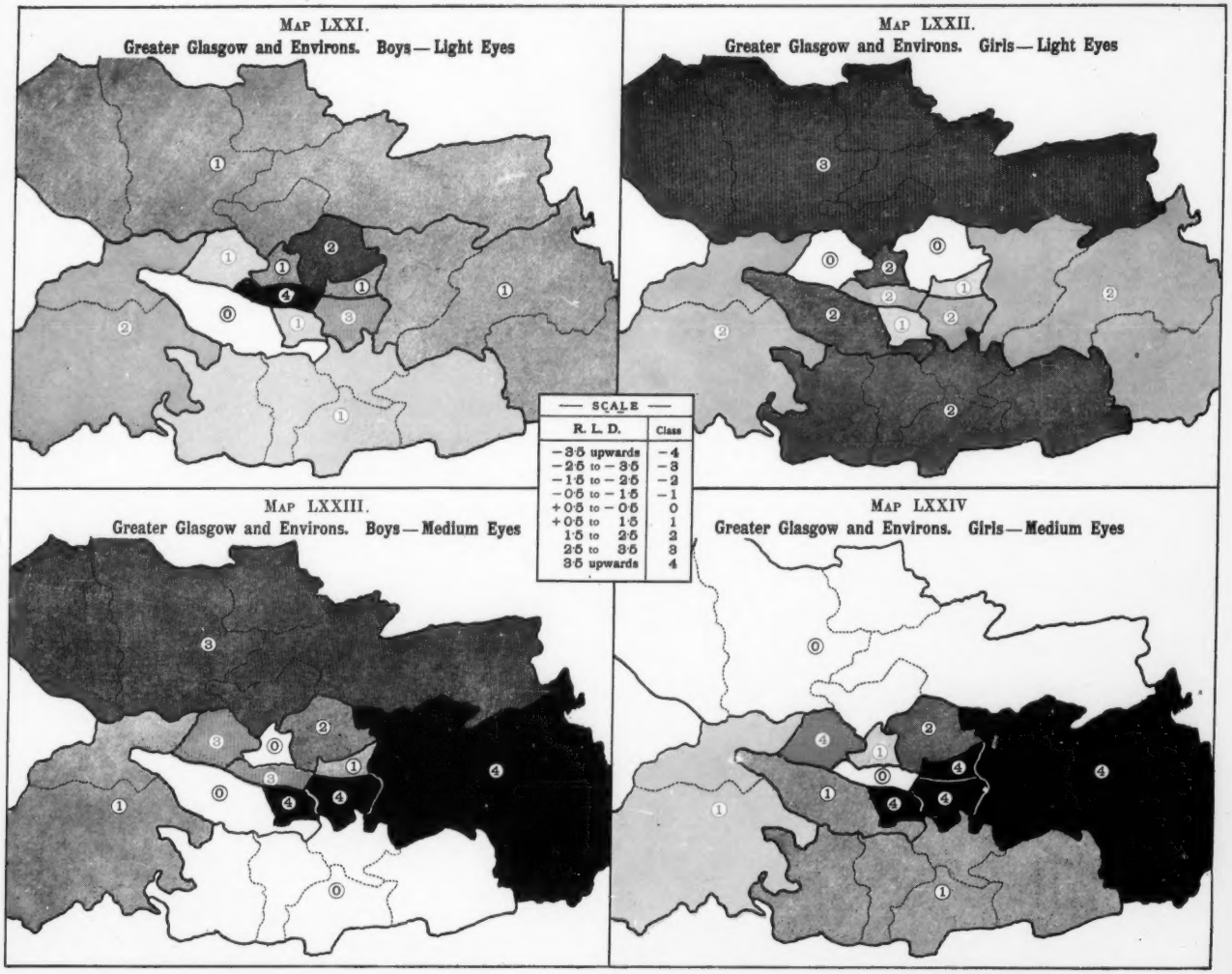
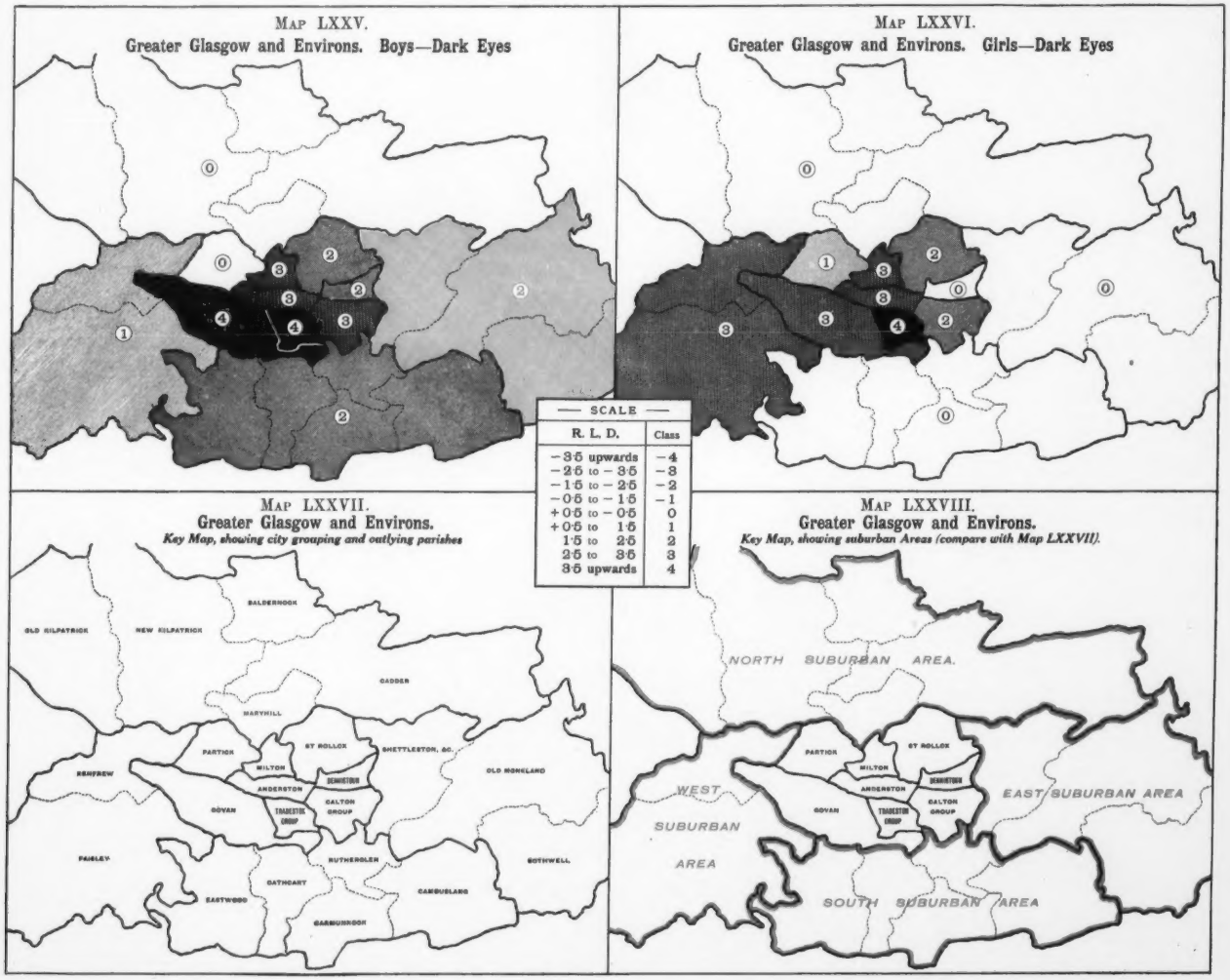
SCALE
R. L. D.
Class
−·35 upwards
−·25 to −·35
−·15 to −·25
−·05 to −·15
+·05 to −·05
·15 to ·25
·25 to ·35
·35 upwards
−4
−3
−2
−1
0
1
2
3
4


MAP LXXI.
Greater Glasgow and Environs. Boys—Light Eyes
MAP LXXII.
Greater Glasgow and Environs. Girls—Light Eyes
MAP LXXIII.
Greater Glasgow and Environs. Boys—Medium Eyes
MAP LXXIV
Greater Glasgow and Environs. Girls—Medium Eyes
SCALE
R. L. D. | Class
−3·5 upwards | −4
−2·5 to −3·5 | −3
−1·5 to −2·5 | −2
−0·5 to −1·5 | −1
+0·5 to −0·5 | 0
+0·5 to 1·5 | 1
1·5 to 2·5 | 2
2·5 to 3·5 | 3
3·5 upwards | 4


MAP LXXV.
Greater Glasgow and Environs. Boys—Dark Eyes
MAP LXXVI.
Greater Glasgow and Environs. Girls—Dark Eyes
— SCALE —
R. L. D. | Class
−3·5 upwards | −4
−2·5 to −3·5 | −3
−1·5 to −2·5 | −2
−0·5 to −1·5 | −1
+0·5 to −0·5 | 0
+0·5 to 1·5 | 1
1·5 to 2·5 | 2
2·5 to 3·5 | 3
3·5 upwards | 4
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Key Map, showing city grouping and outlying parishes
OLD KILPATRICK
NEW KILPATRICK
BALDERNOCK
CADDER
MARYHILL
PARTICK
ST ROLLOX
SHETTLESTON, &C.
MILTON
DENNISTOUN
ANDERSTON
CALTON GROUP
TRADESTON GROUP
GOVAN
RENFREW
OLD MONKLAND
PAISLEY
RUTHERGLEN
BOTHWELL
CATHCART
EASTWOOD
CARMUNNOCK
CAMBUSLANG
MAP LXXVIII.
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Key Map, showing suburban Areas (compare with Map LXXVII).
NORTH SUBURBAN AREA.
WEST SUBURBAN AREA
EAST SUBURBAN AREA
SOUTH SUBURBAN AREA

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VIII.	„	Girls.	„
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X.	„	Girls.	„
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XII.	„	Girls.	„
XIII.	Blue Eyes,	Boys.	„
XIV.	„	Girls.	„
XV.	Light Eyes,	Boys.	VI.
XVI.	„	Girls.	„
XVII.	Medium Eyes,	Boys.	„
XVIII.	„	Girls.	„
XIX.	Dark Eyes,	Boys.	VII.
XX.	„	Girls.	„
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XXII.	„	Girls.	„
XXIII.	Red Hair,	Boys.	VIII.
XXIV.	„	Girls.	„
XXV.	Medium Hair,	Boys.	„
XXVI.	„	Girls.	„
XXVII.	Dark Hair,	Boys.	IX.
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XXX.	„	Girls.	„
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XXXII.	„	Girls.	„
XXXIII.	Light Eyes,	Boys.	„
XXXIV.	„	Girls.	„
XXXV.	Medium Eyes,	Boys.	XI.
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VARIATION, DEVELOPMENT AND GROWTH IN HOLOTHURIA FLORIDANA POURTALÉS AND IN HOLOTHURIA ATRA JÄGER.

By CHARLES LINCOLN EDWARDS, of Trinity College, Hartford, Connecticut.

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I. INTRODUCTION.

A. History of the Subject. Conclusions announced in this Paper.

Pourtalés, 1851, p. 12, described the Holothurid from the muddy flats of the Florida Keys as *Holothuria floridana*. This was recognized as a valid species by Selenka, 1867, pp. 324–6, Pl. 18, Figs. 47–50, but this author probably included part of *H. atra* Jäger, 1833, pp. 22–3, Pl. 3, Fig. 2, in his *floridana*. After investigating a good number of specimens from Florida and the Pacific Ocean, Selenka notes differences in (1) size of calcareous ring, (2) number of ventral pedicels in old individuals, (3) size of end-discs, and (4) number and size of stone-canals, but he concludes that such differences, being only of relative size and not of form, give no ground for specific separation.

Semper, 1868, pp. 88, 92, 278–9, made of Selenka's *atra* the variety *amboinensis* and gave the *floridana* of Pourtalés as a synonym of *H. atra* from Celebes described by Jäger. Since then all authors have followed Semper in relegating *H. floridana* to the synonymy of *H. atra*.

Ludwig, 1874, p. 101, described *H. mexicana* from one small specimen (6 cm. long), without gonads, in the Hamburg Museum under the rather indefinite locality-label of "Mexico." Clark, 1901, p. 258, identified specimens from Porto Rico as *H. mexicana* Ludwig. I have 10 of Clark's specimens included in the series from which my statistics were taken and they are in all respects like the average *H. floridana* as determined in this paper. Hérouard, 1902, p. 8, identified 2 specimens from the Azores as *H. mexicana*, although in some doubt from the fact that the spicules had been dissolved.

Clark, 1902, p. 530, places specimens from Clipperton Island under *H. atra* (Jäger) but is "confident that no less than three distinct species are now included under that name."

Théel, 1886, pp. 174–5, Pl. 8, Fig. 7, described a single specimen from Simon's Bay, Africa, as *H. africana*, and at the end of his description said, "The species in question is possibly identical with Ludwig's *Holothuria mexicana*." In view of the facts established by my studies, I believe we must confirm Théel's suggestion in making *H. africana* and *H. mexicana* identical, and further that the species common from Florida to the Caribbean region is distinct from *H. atra* and therefore, to designate it, the name *H. floridana* Pourtalés should be re-established (Edwards, 1905). The small individual described by Ludwig is, without doubt, a young *H. floridana*, and so *H. mexicana* Ludwig = (*H. africana* Théel) becomes a synonym of *H. floridana* Pourtalés.

The validity of Semper's variety *amboinensis* was questioned by Ludwig, 1883, and denied by Lampert, 1885, and Sluiter, 1902. The last author examined a series of 21 specimens from 12 localities, and found all the intermediate stages

from *H. atra* to the variety *amboinensis*. My studies show that the characters given for the variety have no validity.

B. Material and Methods of Study.

The material subjected to a statistical analysis for this paper includes 138 specimens from the collections of the U.S. National Museum, the Museum of Comparative Zoology, Harvard University, and my own series. For their courtesy in placing specimens in my hands for study, I desire to express my thanks to Dr Richard Rathbun, Assistant Secretary of the Smithsonian Institution, and Dr J. E. Benedict, Assistant Curator, Division of Marine Invertebrates of the U.S. National Museum; and to Dr Alexander Agassiz, Director, Dr W. McM. Woodworth, Assistant, and Dr H. L. Clark, Curator of Echinoderms, of the Museum of Comparative Zoology, Harvard University. I would acknowledge my indebtedness to Dr Charles B. Davenport for his counsel, and also express my appreciation of the skilful and conscientious aid rendered by my assistant, Mr Hubert Dana Goodale.

The various taxonomic characters have been analysed by the biometric methods whose development and application to biological problems are due so largely to the work of Francis Galton and Karl Pearson. In biometry it is important to separate the young specimens from the adult. In the Holothuroidea it is evident that both length and breadth combined in volume must be considered in judging the age. The formula, volume of cylinder $= \pi lr^2$, was adjusted to the more or less shrunken body of the alcoholic specimen and its natural departure from the cylindrical form, by the measurement of the volume of ten individuals in water displacement. It was thus found that the average actual volume is 50 per cent. of the volume estimated by the above formula. Hence I have used the formula $\frac{\pi lr^2}{2}$ to determine the approximate volume of the specimens studied. Mitsukuri, 1903, pp. 13—19, concludes that individuals of *Stichopus japonicus* Selenka taken during the spring and early summer divide themselves into three lots; (1) the adult, (2) the second-year young and (3) the first-year young. From Mitsukuri's tables, in which lengths and diameters are given, I find with the formula $\frac{\pi lr^2}{2}$ that the average volume of the "second-year young" of *Stichopus japonicus* is 113·99 c.c. Mitsukuri concludes "that *Stichopus japonicus* reaches the adult condition in two whole years" therefore the "second-year young," while not sexually mature, are of adult rather than young size. The average volume of the "first-year young" is 43·16 c.c.

In *H. atra* and *H. floridana* I have included in the adult category all of 50 c.c. or greater volume*, realising that such an exact line of division is, to a certain extent, arbitrary, and yet that it is near enough to nature to give in a broad manner the average adult characters for comparison with those of the first-year young. Since it is possible that some of the specimens included in the class may

* One specimen of *H. atra*, volume 49·46 c.c. is given as adult.

be slightly beyond the first-year I will use simply the general term *young* to designate the group.

Mitsukuri, 1897, demonstrated that with advancing age the spicules in *Stichopus japonicus* change so much that "the form distinguished by Théel as var. *typicus* is only a stage in the growth of the species," and from the results of my work I would emphasize Mitsukuri's conclusion as to the important bearing such facts have upon the description of species and the classification of Holothuroidea.

Ludwig, 1898, found in *Phyllophorus urna* that the spicules pass from an Elasipod larval stage to the typical generic type and then, in old age, to secondary rosettes. This author (1898a) also proved in *Cucumaria laevigata* a change in the spicules with advancing age. Östergren, 1898, believed that *Holothuria aphanes* represents the young of *Holothuria impatiens*. The spicules of the former type disappear in the larger specimens and then later are replaced by those peculiar to *Holothuria impatiens*.

Of the 138 specimens available for this paper, 118 are *H. floridana* Pourtalés from the Bahamas, the Florida Keys, Tortugas, Cuba, Porto Rico, Haiti, St Thomas, Swan and Curacoa Islands, Caribbean Sea, and 20 are *H. atra* Jäger from Zanzibar, Mozambique, Arabian Sea, Marshal Is., Samoa, Society Is., Tahite and Hawaiian Is. After completing this study, I have examined specimens from the Galapagos Is. now in the collection of Dr H. L. Clark, which thus extends the range of *H. atra* across the entire Indo-Pacific Ocean.

Simon's Bay, at the Cape of Good Hope, the locality of Théel's *H. africana* is beyond the reported limit of *H. atra* toward that of *H. floridana*. Adopting *H. africana* as a synonym of *H. floridana* it would be interesting to learn whether this species occurs at any places between the southern point of Africa and the Caribbean Sea.

To facilitate comparison, under each character studied I have placed side by side the values for adult and young of the biometric constants, mean, standard deviation or index of variability, and coefficient of variation, each followed by its probable error (±) and at the end the total range of variation of the character. The formulae as given by Davenport, 1904, were used. For graduated variates and integral variates with a class range of more than one, the classes are named from their middle values. For graduated variates with a class range of one, or less than one, the classes are named from their minimum values. The adjectives dorsal and ventral refer to the bivium and trivium respectively. The data for *H. floridana* are presented first, then those for *H. atra* together with comparisons between the two species.

In the summary are given the differential characters which define *H. floridana* Pourtalés and *H. atra* Jäger and upon which I base the re-establishment of the former as a valid species. Finally there is a brief résumé of the additional facts concerning development, growth and variation in common for the two species and then such as are peculiar to each.

Serial Number	Length cm.	Diameter cm.	Volume cm.^{3}	Average Thickness of Skin mm.	Sex	Number of Warts		In Tufts		In Tufts with Branch		
						Right	Left	Number of Tufts	Number of Vesicles in each Tuft	Number of Tufts	Number of Simple Vesicles in each Tuft	Numb Bran Vesi in e Tu
1	18·0	7·6	408·56	5·0	♀	0	0	—	—	—	—	—
2	19·0	5·8	251·00	4·0	♀	15	17	1	2	—	—	—
								1	3	—	—	—
3	20·6	5·2	218·75	5·0	♂	×	×	—	—	—	—	—
4	18·3	5·0	179·66	5·0	♀	0	0	1	2	—	—	—
								1	5	—	—	—
								1	7	—	—	—
								1	10	—	—	—
5	19·0	3·6	96·70	2·0	♂♀	×	×	1	5	—	—	—
6	16·0	3·6	81·44	3·5	♂♀	×	×	1	2	—	—	—
								1	3	—	—	—
7	14·7	4·1	97·04	2·0	♀	×	×	—	—	—	—	—
8	14·0	4·7	121·45	3·0	♂♀	×	×	—	—	—	—	—
9	13·5	3·4	61·29	2·5	♂	×	×	—	—	1	—	1
10	17·3	3·7	84·36	3·0	♂♀	×	×	—	—	—	—	—
11	20·0	5·0	196·35	3·5	♂	×	×	2	2	1	3	—
								3	3	—	—	—
								2	4	—	—	—
								1	5	—	—	—
12	15·2	4·5	120·88	3·5	♀	5	6	1	2	—	—	—
13	12·2	3·8	69·18	2·0	♀	15	19	1	9	—	—	—
14	11·4	5·3	130·55	3·0	♀♂	9*d*	6*d*	1	2	—	—	—
15	17·4	7·5	384·36	4·5	♂	×	×	1	4	—	—	—
								1	6	—	—	—
16	19·2	5·7	244·97	3·5	♂	6	4	4	2	—	—	—
								1	3	—	—	—
								1	4	—	—	—
								2	5	—	—	—
17	23·8	4·1	157·11	4·5	♂	×	×	1	2	1	2	—
								2	3	—	—	—
								3	4	1	2	—
								2	6	—	—	—
								1	7	—	—	—
18	22·1	3·9	132·00	4·0	♂	7	6	1	5	1	1	—
19	22·1	7·3	462·49	—	♀	0	0	—	—	—	—	—
20	19·2	5·2	203·88	—	♂♀	11	7	—	—	—	—	—
21	16·0	4·9	150·86	—	♂♀	7	10	—	—	—	—	—
22	13·3	4·4	101·12	—	♂♀	6	7	—	—	—	—	—
23	12·0	3·8	68·05	—	♂♀	×	×	—	—	—	—	—
24	24·0	7·0	461·82	3·5	♀	0	0	—	—	—	—	—
25	31·0	6·4	498·64	—	+	0	0	—	—	—	—	—
26	22·3	4·2	154·48	—	♀	0	0	—	—	—	—	—
27	10·5	3·6	53·44	2·5	♀	0	0	—	—	—	—	—
28	11·0	3·7	53·64	4·5	♂♀	9	8	—	—	—	—	—
29	9·8	3·8	55·57	2·0	♂♀	0	0	—	—	—	—	—
30	17·4	6·7	306·73	13·0	♂♀	×	×	—	—	—	—	—
31	22·2	5·7	283·25	10·0	♂♀	×	×	—	—	—	—	—
32	21·2	4·8	191·82	6·0	♀	0	0	1	2	—	—	—
33	19·3	6·1	282·02	5·5	♂♀	0	0	—	—	—	—	—
34	18·0	4·8	162·86	10·0	♂♀	×	×	1	4	—	—	—
35	11·5	4·1	75·92	2·0	?	×	×	—	—	—	—	—
36	14·1	4·2	97·68	3·5	♀	*d*	*d*	—	—	—	—	—
37	16·8	6·0	229·03	7·0	♀	0	0	—	—	—	—	—
38	18·0	6·3	271·56	4·5	♂♀	0	0	—	—	—	—	—
39	17·1	3·7	91·93	3·0	♂♀	×	×	1	2	—	—	—
40	19·0	5·1	194·07	2·0	♂♀	×	×	—	—	—	—	—
41	13·8	3·4	62·65	1·5	♂♀	×	×	—	—	—	—	—
42	13·7	3·3	58·75	2·5	♂♀	11*d*	9*d*	—	—	—	—	—
43	13·2	3·2	53·08	2·0	♂♀	8	5	—	—	—	—	—
44	21·4	4·0	134·46	2·5	♂	8	10	—	—	—	—	—

TABLE I.

H. floridana Pourtalés, *Adult.*

Polian Vesicles													Sr
ufts with Branched Vesicles			Solitary			Total Number			Length mm.		Number		
Number of Simple Vesicles in each Tuft	Number of Branched Vesicles in each Tuft	Number of Branches	Branched		Simple	Vesicles	Branches	Vesicles and Branches	Greatest	Least	Right	Left	T
			Number of Vesicles	Number of Branches	Number of Vesicles								
—	—	—	1	13	1	2	13	15	37	1	13	10	
—	—	—	—	—	3	8	—	—	37	2	25	9	
—	—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	1	1	12	15	5	20	40	2	33	36	
			1	2	—	—	—	—	—	—	—	—	
			1	2	—	—	—	—	—	—	—	—	
—	—	—	—	—	3	27	—	—	23	2	10	19	
—	—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	1	5	—	6	5	11	13	7	20	19	
—	—	—	—	—	1	5	—	—	20	2	11	5	
—	—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	3	3	—	—	14	2	10	5	
—	—	—	—	—	1	1	—	—	19	—	14	7	
—	1	1	—	—	2	4	2	6	19	4	14	4	
	1	1	—	—	—	—	—	—	—	—	—	—	
—	—	—	1	1	3	4	1	5	21	2	25	25	
3	—	—	1	2	9	41	4	45	30	1	16	14	
—	—	—	—	—	—	—	—	—	—	—	—	—	
—	1	1	—	—	—	—	—	—	—	—	—	—	
—	1	1	—	—	—	—	—	—	—	—	—	—	
—	—	—	1	1	2	5	1	6	17	3	23	27	
—	—	—	—	—	1	10	—	—	8	1	8	9	
—	—	—	—	—	2	4	—	—	24	3	12	16	
—	—	—	—	—	5	15	—	—	31	2	15	21	
—	—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	1	3	31	58	8	66	22	1	42	27	
—	—	—	1	5	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	—	
2	1	2	1	1	29	79	13	92	22	1	16	4	
—	1	1	1	1	—	—	—	—	—	—	—	—	
2	1	3	1	1	—	—	—	—	—	—	—	—	
—	1	4	—	—	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	—	—	—	—	—	
1	1	1	1	1	3	12	3	15	29	1	21	45	
			1	1	—	—	—	—	—	—	—	—	
—	—	—	—	—	—	—	—	23	22	1	56	27	
—	—	—	—	—	—	—	—	10	28	1	8	6	
—	—	—	—	—	—	—	—	19	13	8	10	6	
—	—	—	—	—	—	—	—	2	39	—	10	6	
—	—	—	—	—	1	1	—	—	51	—	9	4	
—	—	—	—	—	—	—	—	25	30	1	23	21	
—	—	—	—	—	—	—	—	11	53	3	39	44	
—	—	—	—	—	—	—	—	7	17	1	10	8	
—	—	—	—	—	3	3	—	—	22	5	11	5	
—	—	—	—	—	1	1	—	—	11	—	5	2	
—	—	—	—	—	1	1	—	—	16	—	7	3	
—	—	—	—	—	2	2	—	—	14	3	63	18	
—	—	—	1	4	—	1	4	5	13	—	21	14	
—	—	—	—	—	7	9	—	—	35	2	39	21	
—	—	—	—	—	1	1	—	—	23	—	33	23	
—	—	—	—	—	—	4	—	—	30	3	21	20	
—	—	—	—	—	3	3	—	—	21	1	16	11	
—	—	—	—	—	—	—	—	9	40	1	18	14	
—	—	—	—	—	1	1	—	—	?	?	7	8	
—	—	—	—	—	—	—	—	17	24	2	46	18	
—	—	—	—	—	1	3	—	—	23	5	4	1	
—	—	—	—	—	1	1	—	—	28	—	18	21	
—	—	—	—	—	1	1	—	—	16	—	22	4	
—	—	—	—	—	1	1	—	—	25	—	9	4	
—	—	—	—	—	1	1	—	—	25	—	5	2	

Stone Canals					Number		Pedicels and Papillae; Distribution per sq. cm.		Museum Number		
Number			Length								
ght	Left	Totals	Greatest	Average	Tentacles	Groups of Anal Papillae	Dorsal	Ventral	U.S. National Museum	Harvard	Edwards
13	10	23	10	6·5	19	5	12	37	—	—	1
25	9	34	12	7·0	20	*i*	13	31	—	—	2
—	—	—	—	—	—	—	—	—	—	—	—
33	36	69	6	4·0	20	*i*	22	39	—	—	3
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
10	19	29	13	8·5	20	5	12	21	—	—	0a
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
20	19	39	21	7·5	16	5	18	34	—	—	0b
11	5	16	6	4·5	18	5	16	17	—	—	0c
—	—	—	—	—	—	—	—	—	—	—	—
10	5	15	14	5·5	20	5	17	23	—	—	0e
14	7	21	9	6·0	20	5	16	34	—	—	4a
14	4	18	10	4·0	20	5	18	31	—	—	4b
—	—	—	—	—	—	—	—	—	—	—	—
25	25	50	4	3·5	20	4	16	25	—	—	4c
6	14	30	21	10·5	20	5	10	22	—	—	4d
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
23	27	50	12	6·0	20	5	13	41	—	—	6a
8	9	17	6	4·5	20	4	13	41	—	—	0d
2	16	28	8	4·5	20	5	15	32	—	—	0f
5	21	36	16	8·0	20	*i*	12	35	14714	—	—
—	—	—	—	—	—	—	—	—	—	—	—
42	27	69	8	6·5	20	5	12	35	14714	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
16	4	20	15	7·0	20	5	14	29	14715	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
21	45	66	14	9·5	20	3	12	21	14715	—	—
—	—	—	—	—	—	—	—	—	—	—	—
56	27	83	7	5·0	22	5	15	30	—	1057	—
8	6	14	7	5·5	18	5	14	29	—	„	—
10	6	16	5	4·0	20	4	12	33	—	„	—
10	6	16	9	6·5	20	4	19	30	—	„	—
9	4	13	6	4·5	20	*i*	16	50	—	„	—
23	21	44	5	3·5	20	*c*	12	32	—	614	—
39	44	83	10	8·0	20	5	16	22	—	592	—
10	8	18	5	4·0	20	5	7	6	16720	—	—
11	5	16	3	2·5	20	5	10	17	—	—	7a
5	2	7	7	5·5	18	?	14	20	—	—	7b
7	3	10	4	3·5	20	5	9	22	—	—	7d
53	18	81	10	5·0	21	5	11	16	16717	—	—
21	14	35	7	6·0	20	5	7	9	„	—	—
39	21	60	5	4·0	20	5	12	17	„	—	—
33	23	56	5	4·0	20	4	12	17	„	—	—
21	20	41	5	3·0	22	5	10	15	„	—	—
16	11	27	4	3·0	19	5	10	26	16712	—	—
18	14	32	6	5·0	20	*i*	17	40	—	?	—
17	8	15	8	7·0	19	5	18	34	—	?	—
46	18	64	7	6·5	20	5	16	28	—	?	—
14	1	5	4	3·0	20	5	18	13	16721	—	—
18	21	39	5	4·0	18	4	12	16	16697	—	—
12	4	26	4	3·0	19	4	15	22	„	—	—
9	4	13	5	3·5	20	*i*	10	16	16698	—	—
5	2	7	7	4·5	20	5	12	32	16699	—	—

42	13·7	3·3	58·75	2·5	♀♂	×	×	—	—	—	—	—
43	13·2	3·2	53·08	2·0	♀	11*d*	9*d*	—	—	—	—	—
44	21·4	4·0	134·46	2·5	♂	8	5	—	—	—	—	—
45	18·4	4·4	139·89	3·0	♂	8	10	—	—	—	—	—
46	16·0	4·4	121·64	2·0	♀♂	10	10	—	—	—	—	—
47	19·1	4·1	126·09	3·5	♀	8	6	—	—	—	—	—
48	14·0	3·4	63·56	7·0	♀	×	×	1	3	—	—	—
49	9·7	3·7	52·15	1·0	♀	13	15	—	—	—	—	—
50	15·0	5·7	191·38	—	♀	14	9	—	—	—	—	—
51	18·5	7·0	355·99	—	♂	0	0	—	—	—	—	—
52	11·3	4·3	82·05	2·0	♀♂	6	5	—	—	—	—	—
53	9·0	3·8	51·04	1·5	♀♂	0	0	—	—	—	—	—
54	10·0	3·9	59·73	3·0	♀	0	0	—	—	—	—	—
55	16·0	4·8	144·76	3·5	♂	0	0	—	—	1	3	1
56	25·2	7·0	484·91	1·0	♂	6	5	—	—	—	—	—
57	16·1	3·9	88·12	1·5	♂	0	0	—	—	—	—	—
58	15·6	7·7	365·42	2·5	♂	×	×	1	2	—	—	—
59	18·5	5·8	244·40	4·0	♂	×	×	—	—	—	—	—
								1	3	—	—	—
								1	5	—	—	—
								2	7	—	—	—
60	26·7	6·4	429·47	2·5	♀	×	×	—	—	—	—	—
61	17·5	5·6	215·52	7·5	♀	0	0	—	—	—	—	—
62	14·9	5·3	164·36	6·0	♀	0	0	—	—	1	1	1
63	15·0	3·3	64·09	1·0	♀	0	0	—	—	—	—	—
64	24·5	8·1	631·15	6·0	♂	×	×	—	—	—	—	—
65	32·4	7·7	754·40	—	♀	0	0	—	—	—	—	—
66	32·7	8·3	884·64	—	♂	0	0	—	—	—	—	—
67	20·9	6·1	305·40	5·0	♂	0	0	3	2	—	—	—
								1	3	—	—	—
68	19·6	6·0	277·09	3·5	♀	0	0	1	2	—	—	—
								1	3	—	—	—
69	17·2	7·0	330·97	5·0	♀	×	×	—	—	—	—	—
70	16·2	7·3	339·02	7·0	♀	×	×	3	2	1	3	1
								1	3	—	—	—
								1	4	—	—	—
71	14·4	3·6	73·29	3·5	♂	11	9	—	—	—	—	—
72	15·4	7·2	313·51	5·5	♂	0	0	1	2	—	—	—
										—	—	—
73	18·4	6·0	260·13	5·5	♂	0	0	3	2	1	1	1
								1	3	—	—	—
								2	4	—	—	—
								1	5	—	—	—

† Missing. + Undifferentiated. × Traces. *d* Some in bivium. *i* Indefinite. *c* In a circle
united. *11* has one stone-canal with 2 branches. *32* has an extra ventral tuft of 4 stone-canals. *1—1*
who presented these specimens, collected in the Bahamas and since Clark, 1899, pp. 122—3, says *H.*
Key; *36—38*, Bahia Honda; *39*, between Salt Pond Key and Stock Is.; *40—49*, Key West; *50—53*,
72—73, Curacoa I.

Originally *24*, *25* and *51* were identified as *Mülleria agassizii* Selenka; *50*, *52*, *53* and *64* as *Holoth*

To face p. 239

—	—	—	—	—	1	1	—	—	16	—	22	4	26
—	—	—	—	—	1	1[c]	—	—	25	—	9	4	13
—	—	—	—	—	1	1	—	—	25	—	5	2	7
—	—	—	—	—	1	1	—	—	28	—	15	11	26
—	—	—	—	—	3	3	—	—	32	3	13	7	20
—	—	—	—	—	—	?	—	—	?	—	12	6	18
—	—	—	—	—	4	7	—	—	38	1	13	9	22
—	—	—	—	—	4	4	—	—	30	1	9	5	14
—	—	—	—	—	—	?	—	—	—	—	4	3	7
—	—	—	—	—	—	—	—	6	58	1	27	9	36
—	—	—	—	—	—	—	—	12	40	1	20	11	31
—	—	—	—	—	2	2	—	—	26	10	6	5	11
—	—	—	—	—	1	1	—	—	19	—	9	3	12
3	1	1	—	—	11	15	1	16	19	2	16	21	37
—	—	—	1	3	11	12	3	15	16	1	51	15	66
—	—	—	—	—	19	19	—	—	8	1	17	15	32
—	—	—	—	—	5	7	—	—	17	1	18	10	28
—	—	—	—	—	3	3	—	—	10	8	29	28	57
—	—	—	—	—	15	37	—	—	22	1	23	20	43
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	4	4	—	—	14	1	11	24	35
—	—	—	1	2	6	7	2	9	28	1	52	34	86
1	1	4	1	2	4	7	6	13	19	1	25	14	39
—	—	—	—	—	12	12	—	—	23	1	28	24	52
—	—	—	—	—	—	—	—	8	16	9	30	22	52
—	—	—	—	—	—	—	—	29	15	1	43	21	64
—	—	—	—	—	—	—	—	14	14	1	35	38	73
—	—	—	—	—	4	13	—	—	20	1	15	26	41
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	19	24	—	—	21	1	88	61	149
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	13	13	—	—	31	1	32	23	55
3	1	1	1	1	13	31	2	33	16	1	24	39	63
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	3	3	—	—	18	2	7	5	12
—	—	—	1	1	10	14	6	20	73	1	34	18	52
—	—	—	1	5	—	—	—	—	—	—	—	—	—
1	1	2	—	—	16	40	2	42	37	1	26	20	46
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—

[c] In a circle. In *40* the Polian vesicle arises from the right dorsal radial canal just below the calcareous ring. In *A*
ne-canals. *1—14*, Bahamas, Abaco, Green Turtle Cay; *15—16*, New Providence; *17—18*, New Providence Nassau; *19—23*,
22—3, says *H. floridana* does not occur in the Bermudas, I have seriated the specimens as Bahaman; *24—53*, Florida
West; *50—53*, Tortugas; *54—63*, Porto Rico; *54—58*, Boqueron Bay; *59—60*, Fajardo; *61—62*, Mayaquez; *63*, San Ju

nd *64* as *Holothuria floridana* Pourtalés; *54—63* as *H. mexicana* Ludwig, and the others of the Harvard and U.S. Natio

18	21	39	5	4·0	18	4	12	16	16697	—	—
22	4	26	4	3·0	19	4	15	22	,,	—	—
9	4	13	5	3·5	20	*i*	10	16	16698	—	—
5	2	7	7	4·5	20	5	13	23	16699	—	—
15	11	26	4	3·5	20	5	8	16	16697	—	—
13	7	20	4	3·0	18	*c*	9	16	,,	—	—
12	6	18	7	5·5	20	5	9	21	16892	—	—
13	9	22	6	5·0	20	5	9	15	16716	—	—
9	5	14	7	6·0	20	5	13	20	,,	—	—
4	3	7	5	4·0	20	5	10	20	16699	—	—
27	9	36	10	7·0	20	*i*	17	39	—	1061	—
20	11	31	10	7·0	20	*i*	22	32	—	614	—
6	5	11	5	4·5	19	5	15	20	—	405	—
9	3	12	3	2·5	20	5	10	21	—	36	—
16	21	37	5	4·0	20	6	13	25	19669	—	—
51	15	66	5	4·5	19	5	14	18	,,	—	—
17	15	32	6	5·0	20	5	10	14	,,	—	—
18	10	28	3	1·5	19	5	11	15	,,	—	—
29	28	57	5	3·5	20	4	6	14	,,	—	—
23	20	43	13	6·5	20	5	13	30	19667	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
11	24	35	11	7·5	20	5	13	23	19667	—	—
52	34	86	11	5·5	21	*i*	11	18	19672	—	—
25	14	39	8	4·5	21	*i*	13	26	,,	—	—
28	24	52	3	3·0	18	5	20	23	19673	—	—
30	22	52	8	7·0	20	*i*	11	22	—	132	—
43	21	64	5	5·0	20	5	17	24	—	74	—
35	38	73	8	7·0	19	*c*	11	27	—	74	—
15	26	41	7	5·0	20	5	10	25	7501	—	—
—	—	—	—	—	—	—	—	—	—	—	—
88	61	149	5	4·5	20	2	13	36	7501	—	—
—	—	—	—	—	—	—	—	—	—	—	—
33	23	55	6	4·5	20	5	14	30	7502	—	—
24	39	63	5	4·0	20	5	13	26	,,	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
7	5	12	6	5·5	20	*i*	19	26	17064	—	—
34	18	52	10	6·0	20	0	13	22	7427	—	—
—	—	—	—	—	—	—	—	—	—	—	—
26	20	46	9	7·5	21	*c*	12	26	7427	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—

e calcareous ring. In *12*, 2 stone-canals arise 2 mm. from main tuft. *9* has several madreporites idence Nassau; *19—23*, under label, "Bermudas," but the Harvard records show that Dr H. Bryant, man; *24—53*, Florida; *24—26*, Florida; *27—29*, Elliots' Key; *30—34*, Caesar's Creek; *35*, Vaca Mayaquez; *63*, San Juan; *64*, Hayti; *65—70*, St Thomas; *71—73*, Caribbean Sea; *71*, Swan Ia.;

Harvard and U.S. National Museums as *H. atra* Jäger.

II. HOLOTHURIA FLORIDANA POURTALÉS.

A. Body.

a. FORM.

The cylindrical body tapers somewhat more posteriorly than anteriorly and is flattened in the trivium upon which it generally creeps. At the anterior end the mouth is ventral while the anus is terminal posteriorly. As the Holothurid pushes itself along over the slimy whitish coralline sand of the bottom, from the low tide mark to one, or a few fathoms, in depth, pieces of dead water-weeds, small shells and calcareous debris are caught up among the dorsal ambulacral appendages and serve as an excellent protective mask.

b. SIZE.

TABLE III.

1. *Length in cm.*

Alcoholic specimens measured while straightened out on a table and placed between two glass plates.

	Adult	Young
Number of specimens ...	73	45
Mean	17·656 ± ·390	6·694 ± ·344
Standard Deviation ...	4·939 ± ·276	3·517 ± ·240
Coefficient of Variation ...	29·972 ± 1·561	52·541 ± 3·736
Range of Variation ...	9—32·7	1·7—15·4

Selenka, 1867, p. 325, gives several individuals 35 cm. long.

TABLE IV.

2. *Diameter in cm.*

Greatest obtainable taken with a pair of dividers.

	Adult	Young
Number of Specimens ...	73	45
Mean	5·149 ± ·120	1·983 ± ·071
Standard Deviation ...	1·512 ± ·084	·816 ± ·047
Coefficient of Variation ...	29·361 ± 1·640	40·614 ± 2·878
Range of Variation ...	3·2—8·3	·6—3·4

TABLE II. *H. floridana Pourtalés. Young.*

Serial Number	Length cm.	Diameter cm.	Volume cm.³	Average Thickness of Skin mm.	Sex	Number of Warts		Total Number Polian Vesicles	Length mm.		Stone Canals					Tentacles	Groups of Anal Papillae	Pedicels and Papillae Distribution per sq. cm.		Smithsonian Institution	Harvard	Edwards
											Number			Length mm.								
						Right	Left		Greatest	Least	Right	Left	Total	Greatest	Average			Dorsal	Ventral			
74	7·3	2·4	16·51	2·0	♂	10	9	1	18	—	3	1	4	7	5·0	20	5	17	40	14713	—	—
75	7·7	2·5	18·90	1·5	♀	7	0	1	17	—	6	4	10	7	4·5	20	5	18	41	,,	—	—
76	10·0	2·9	33·03	1·5	♂	10	12	1	29	—	10	5	15	7	6·0	20	5	11	28	,,	—	—
77	4·4	1·3	2·92	0·7	+	12	6	1	14	—	5	4	9	3	3·0	18	5	40	128	,,	—	—
78	6·2	2·3	12·88	0·5	♂	9	9	1	11	—	6	4	10	4	3·5	20	*i*	40	60	,,	—	—
79	9·5	2·6	25·22	1·5	♂	0	5	2	12	11	13	2	15	7	5·0	20	*i*	19	45	,,	—	—
80	10·1	3·4	45·85	1·5	♀	9	9	2	15	14	10	7	17	6	5·0	18	5	9	23	,,	—	—
81	9·6	3·0	33·93	2·0	♂	10	10	1	25	—	5	2	7	7	4·5	20	5	11	28	,,	—	—
82	2·3	1·1	1·08	1·0	♂	5	5	2	4	1	5	0	5	2	2·0	18	5	34	48	14715	—	—
83	11·0	2·7	31·49	3·0	♂	×	×	1	8	—	15	4	19	6	6·0	20	5	20	19	—	200	—
84	6·5	1·7	7·38	3·0	♂	6	8	1	14	—	6	3	9	3	3·0	20	5	20	68	—	662	—
85	7·0	1·6	7·04	2·0	+	×	×	4	4	1	4	1	5	1	1·0	20	5	26	36	—	230	—
86	15·5	1·9	21·98	—	?	8	10	5	7	2	1	1	2	2	1·5	20	4	20	40	—	230	—
87	8·1	3·1	26·52	2·5	♂	7	7	1	10	—	6	5	11	5	4·5	20	*i*	10	12	—	—	7*c*
88	8·4	1·6	8·45	2·5	♀	*d*	*d*	1	2	—	14	11	25	3	2·0	19	5	22	14	16166	—	—
89	5·0	1·4	3·85	1·5	♀	7	8	1	5	—	8	2	10	2	1·0	18	5	23	35	,,	—	—
90	5·0	1·6	5·03	0·7	?	6	9	2	5	3	5	3	8	3	2·0	20	5	17	13	,,	—	—
91	15·4	2·5	37·80	2·5	♂	12	11	3	13	8	7	8	15	5	2·0	20	*i*	12	18	16714	—	—
92	10·6	2·8	32·64	2·5	♂	14	12	1	26	—	12	9	21	3	3·0	20	4	15	28	16712	—	—
93	8·6	1·9	12·19	0·3	♀	11	10	1	6	—	3	1	4	3	3·0	20	5	16	27	16698	—	—
94	8·9	2·7	21·03	1·0	♀	7	5	1	15	—	3	2	5	4	3·5	20	5	12	20	,,	—	—
95	9·4	2·6	24·95	2·0	+	10	10	1	?	—	1	3	4	7	5·0	20	*i*	35	45	,,	—	—
96	5·6	2·1	9·70	1·0	♀	8	7	1	9	—	3	3	6	4	3·0	20	3	18	27	16706	—	—
97	3·6	1·5	3·18	0·1	+	8	8	1	6	—	2	2	4	1	1·0	19	5	14	28	,,	—	—
98	3·9	1·5	3·45	0·5	?	7	5	1	6	—	4	3	7	3	2·0	20	5	17	27	16709	—	—
99	3·1	1·6	3·12	1·0	+	5	8	1	5	—	6	2	8	1	1·0	20	5	16	28	,,	—	—
100	2·8	1·1	1·33	0·2	+	×	×	1	4	—	2	2	4	1	1·0	20	5	19	44	,,	—	—
101	2·9	1·4	2·23	0·4	+	5	6	1	5	—	5	2	7	2	1·5	20	5	23	42	,,	—	—
102	1·7	0·8	0·43	0·1	?	3	4	1	2	—	2	1	3	1	1·0	19	4	26	30	,,	—	—
103	1·8	0·8	0·46	0·1	?	0	0	1	3	—	2	2	4	1	1·0	20	5	20	36	,,	—	—
104	1·8	0·6	0·26	0·1	?	4	4	1	3	—	3	2	5	1	1·0	20	0	44	60	,,	—	—
105	3·0	1·1	1·43	1·0	+	10	7	1	6	—	2	5	7	2	2·0	20	5	32	46	,,	—	—
106	1·9	1·0	0·75	1·0	?	1	3	1	2	—	4	5	9	1	1·0	20	5	26	40	7556	—	—
107	1·8	0·8	0·46	1·0	?	*i*	8	1	4	—	2	1	3	1	1·0	20	*i*	28	36	,,	—	—
108	7·3	2·0	11·47	1·0	♀	7	4	4	11	1	7	5	12	2	2·0	20	5	14	22	16702	—	—
109	6·6	2·3	13·71	1·0	+	×	×	1	12	—	11	5	16	3	2·0	20	5	14	19	,,	—	—
110	3·9	1·2	2·21	1·0	+	3	8	0	—	—	4	1	5	3	3·0	20	4	21	29	,,	—	—
111	5·8	2·0	9·11	1·5	+	9	11	1	12	—	5	1	6	2	1·0	19	6	24	22	,,	—	—
112	10·6	3·3	40·03	1·5	♀	7	3	16	19	1	11	5	16	3	2·5	20	*i*	12	18	16699	—	—
113	10·7	2·8	32·95	1·0	♀	6	7	6	23	2	13	6	19	3	3·0	21	5	16	20	16892	—	—
114	8·0	2·5	15·64	2·0	♂	9	8	2	9	2	9	4	13	2	1·0	20	5	22	36	—	587	—
115	4·0	1·5	3·54	1·5	+	10	11	1	7	—	5	3	8	1	1·0	20	5	30	64	—	587	—
116	7·7	2·0	12·10	2·0	♂	10	8	8	10	2	4	4	8	5	4·0	20	5	19	59	—	587	—
117	7·9	2·8	24·33	2·0	♂	12	9	1	13	—	7	5	12	3	2·0	20	5	16	24	—	—	—
118	9·8	3·0	34·64	2·0	♀	×	×	1	6	—	11	4	15	5	4·5	20	5	8	11	—	—	—

? missing. + undifferentiated. × traces. *d* some dorsally. *i* indefinite. In 75 the Polian vesicle is near the mesentery on the left side. 112 has 1 tuft with 2 Polian vesicles and 113 has 1 tuft with 3 vesicles. 74, 81, 87—89, 91, 96 and 97 have warts on the bivium in addition to the right and left lateral rows and 76 has one row in the region of each dorsal radius. 74—81 from Abaco. 82, Nassau, New Providence, Bahamas. 83—116, Florida; 83—86, Cape Florida; 87, Elliot's Key; 88—90, Key Largo; 91, Indian Key; 92, Vaca Key; 93—113, Key West; 114—116, Tortugas. 117, 118, Havana, Cuba. 83—87 were originally identified as *Holothuria floridana* Pourtalés, the others as *H. atra* Jäger.

TABLE V.

3. . *Volume in cm.*^{3} $v = \frac{\pi l r^2}{2}$

	Adult	Young
Number of Specimens ...	73	45
Mean	209·584 ± 13·185	12·506 ± ·645
Standard Deviation ...	167·025 ± 9·323	6·511 ± ·463
Coefficient of Variation ...	79·679 ± 4·450	52·076 ± 3·701
Range of Variation ...	51·04—884·64	·26—45·85

B. Development and Growth.

During the summer of 1888 I reared the young of this species at Green Turtle Cay, Abaco, Bahamas, (Edwards, 1889)*. During the first 5 days the embryo

TABLE VI.

Age in Days	Number of Specimens	Length mm.	Average Diameter mm.	Volume cm.^{3} $\left(\frac{\pi l r^2}{2}\right)$
5	3	·33	·28	·0102
7	3	·31	·25	·0076
9	3	·30	·27	·0086
10	3	·27	·27	·0077
11	6	·40	·26	·0106
12	6	·42	·24	·0095
13	3	·47	·23	·0097
14	8	·41	·20	·0064
15	3	·37	·18	·0046
18	8	·34	·30	·0120
19	3	·34	·33	·0145
20	3	·42	·30	·0148
22	6	·36	·32	·0145
24	2	·50	·32	·0101
30	3	1·00	·48	·0905
33	1	1·40	·45	·1113
40	2	1·65	·65	·2737
42	2	2·00	·68	·3632
45	3	1·70	·93	·5773
49	2	2·30	·68	·4176
51	2	2·10	·90	·6680
53	3	2·05	·72	·4173
55	2	2·30	·85	·6525
67	1	2·30	·90	·7316
71	2	2·95	·95	1·0454
75	2	4·00	·95	1·4175
87	2	2·30	·75	·5080
88	2	1·95	·85	·3726

* The erroneous identification of this Holothurid with *Mülleria agassizii* Selenka was made, without reference to the taxonomic literature, from the label of a specimen in the biological museum of the Johns Hopkins University. Table I. in the present paper shows that three individuals were thus identified in the Harvard collections. Naturally such errors are due to the most superficial examination.

Bahamas, 83—116, Florida; 83—86, Cape Florida; 87, Elliot's Key; 89—90, Key Largo; 91, Indian Key; 92, Vaca Key; 93—113, Key West; 114—116, Tortugas. 117, 118, Havana, Cuba. 83—87 were originally identified as *Holothuria floridana* Pourtales, the others as *H. atra* Jäger.

develops within the vitelline membrane. In the fourth day it has four tentacles and a budding posterior ventral pedicel (Edwards, 1907, pp. 775—776). In the sixth day after fertilization the embryo breaks its way through the slime covered egg membrane. The larval Holothurid has a primitive symmetry of five tentacles and one posterior ventral pedicel by means of which it creeps about. At times it is erect upon this posterior pedicel in a Hydra-like attitude. Then again it comes down on its tentacles while the pedicel is released from the bottom of the dish and waved aloft. It is nourished from the micro-organisms in the slime of the aquarium. This slime is left at each change of water so that the algae and other protists multiply and thus furnish a good supply of food.

Table VI. shows the growth in length*, diameter and volume of 89 of these very young individuals from the fifth, or last day within the vitelline membrane, to 88 days of age. In general there is a progressive increase in size up to 75 days. The diminution in volume of the individuals for 87 and 88 days undoubtedly indicates stunting from lack of food and other conditions in the small aquaria.

C. Colour.

a. Living and Alcoholic Specimens.

On July 11, 1891, at Harbour Island, Bahamas, the colours of 25 living specimens were determined by comparison with Ridgway, 1886. Besides the usual colours shown in the following analyses of alcoholic specimens, coral-red, scarlet and scarlet-vermilion were each found in two individuals and flame-scarlet in one. These colours have disappeared from the specimens which have remained in alcohol. Ludwig, 1889–92, p. 27, points out that certain pigments like yellow, yellowish-red and red are changed by alcohol. However, in the Holothurids considered in this paper the masses of pigment are so thick that in most cases, excepting those noted above, the colours here recorded for the alcoholic specimens may be accepted as about the same as those of the living individuals. Since ordinarily, for taxonomy, museum rather than living examples are studied it is certainly important to have the colours properly taken and recorded from alcoholic specimens, if it is not possible at the same time to have them for comparison from the animals while alive.

b. Methods of Determination.

The colour was determined, on a clear day, with Ridgway, 1886, as the standard. In Tables VII. and VIII. a summary of the colouration and the distribution of the colours of the pedicels and papillae and the body is given for the bivium and trivium. The "stalk" is that portion of an appendage extending from the body-wall to within about ·5 mm. from the distal termination where usually the "end" is marked off by a ring around the tip. In the absence of the ring the "stalk" extends to the sucker. Sometimes, especially dorsally, the appendages arise from

* Measured from base of tentacles to proximal end of the posterior ventral pedicel.

slight elevations, "warts," or in other cases from spots, or rings, differing in colour from the surrounding portions. For the body the mid-dorsal and lateral-dorsal regions correspond to the similar regions of the bivium. The trivium is often sharply marked off and occupies about two-fifths of the circumference of the animal. The mid-dorsal and lateral-dorsal regions are not always to be differentiated. Sometimes the differing lateral colour is along the dorsal edge of the side. "Dots" are minute bits of colour up to ·2 mm. diameter; "spots" are from ·2 mm. to 1 cm. in diameter, while "blotches" are larger areas often extending over a considerable portion of the surface. Light colour like cream is often due to heaps of spicules visible through the skin.

The colouration is very variable as given in Table VII. and represented in Plate II. for the adult and in Plate I. for the young. The general statement of colouration is given in a brief and untechnical form by grouping the following

TABLE VII.

		Ambulacral Appendages										Body					
		Dorsal Stalks		Dorsal Ends		Ventral Stalks		Ventral Ends		Origin		Mid-Dorsal		Lateral-Dorsal		Ventral	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Adult, 73 Specimens	Number of Colours	21	—	15	—	22	—	18	—	10	—	24	—	28	—	20	—
	Browns ...	67[a]	73·7	67[a]	92·0	38[b]	49·4	70[c]	91·0	11	58·0	90[d]	79·1	106[e]	72·1	56[f]	56·0
	Creams ...	11	12·1	5	6·9	8	10·4	4	5·2	1	5·3	10	8·7	24	16·4	34	34·0
	Grays ...	13	14·3	—	—	25	32·5	3	3·9	2	10·5	14	12·3	16	10·9	8	8·0
	Black ...	—	—	1	1·4	1	1·4	—	—	4	21·0	—	—	1	·7	1	1·0
	White ...	—	—	—	—	5	6·5	—	—	1	5·3	—	—	—	—	—	—
Young, 45 Specimens	Number of Colours	15	—	15	—	14	—	15	—	6	—	26	—	25	—	21	—
	Browns ...	40[g]	60·0	54[h]	81·7	27[g]	43·5	49[i]	89·0	5[j]	25·0	61[k]	38·7	65[l]	38·7	28	30·5
	Creams ...	19	28·4	6	9·0	19	30·7	5	9·1	1	5·0	28	17·9	34	20·3	27	29·1
	White ...	4	6·0	—	—	6	9·7	1	1·8	—	—	4	2·5	5	3·0	4	4·3
	Grays ...	3	4·5	6	9·1	9	14·5	—	—	1	5·0	63	40·0	61	36·5	32	34·5
	Black ...	1	1·5	—	—	1	1·6	—	—	13	65·0	1	·6	3	1·8	2	2·2

[a] Dark tints; seal, clove, predominant. [b] Tints, well distributed; seal, sepia and drab about alike. [c] Tints, distributed; seal, clove, sepia and clay-colour well marked. [d] Dark tints; seal, clove, Vandyke prominent. [e] Seal, clove, sepia, Prout's, Broccoli, drab and cinnamon prominent. [f] Tints well distributed; seal, clove, drab and cinnamon more pronounced. [g] Light tints; Prout's and clay-colour prominent. [h] Light tints; cinnamon and especially clay-colour prominent. [j] Seal, cinnamon and clay-colour. [k] Tints well distributed; seal, clove, sepia, Vandyke, Prout's, Isabella and clay-colour the more prominent. [l] Seal, clove, Prout's, Isabella and clay-colour prominent.

TABLE VIII.

Distribution of Colours on the Body expressed in Percentages.

		Whole Body Uniform	Mid-Dorsal			Lateral-Dorsal			Ventral		
			Uniform	Mixed		Uniform	Mixed		Uniform	Mixed	
				Ground	Markings		Ground	Markings		Ground	Markings
		12·3[a]	60·3[b]	—	—	28·8[c]	—	—	57·5[d]	—	—
Adult, 73 Specimens	Browns	—	—	77·7	53·8	—	81·0	50·0	—	53·1	57·1
	Creams	—	—	23·7	19·2	—	13·9	20·8	—	43·8	14·3
	Grays	—	—	3·6	26·9	—	3·8	29·2	—	3·1	28·6
	Black	—	—	—	—	—	1·3	—	—	—	—
		4·4[e]	—	—	—	6·6[f]	—	—	33·3[g]	—	—
Young, 45 Specimens	Browns	—	13·2	65·8	26·8	—	65·9	24·6	—	42·4	14·3
	Creams	—	—	18·4	28·1	—	20·5	30·4	—	36·3	32·1
	Grays	—	—	15·8	42·3	—	9·1	40·6	—	21·3	39·3
	Black	—	—	—	—	—	4·5	—	—	—	—
	White	—	—	—	2·8	—	—	4·4	—	—	14·3

[a] Mostly seal and clove-brown. [b] Mostly seal-brown. [c] Seal-brown, lighter browns and 1 cream-colour. [d] Lighter browns and creams. [e] Prout's brown and black. [f] Isabella-colour and cream. [g] Browns, creams, grays and 2 in black.

colours so that the 25 tints from seal-brown to clay-colour are the "*browns*," the 4 tints from cream-buff to cream-colour the "*creams*," and the 9 tints from slate-colour to pearl-gray the "*grays*," while black and white stand independently. *Browns:* seal, clove, sepia, chocolate, Vandyke, bistre, walnut, burnt umber, olive, mummy, Prout's, hair, Mars, raw umber, Broccoli, russet, tawny olive, drab, wood, cinnamon, écru drab, fawn-colour, Isabella-colour, ochraceous rufous, clay-colour. *Creams:* cream-buff, buff, buff-yellow, cream-colour. *Black. Grays:* slate-colour, slate-gray, gray, drab-gray, olive-gray, plumbeous, lilac-gray, lavender-gray, pearl-gray. *White.*

c. Colouration.

1. *Pedicels and Papillae.*

The dorsal stalks of the adult are chiefly dark brown while in the young the lighter browns prevail together with relatively more of the creams. In the ventral stalks of both adult and young the browns are less prominent than dorsally, and there is a marked increase in the grays and white. In the appendages all over the body the ends show a considerable increase in the browns over those characteristic for the stalks of the regions. In both adult and young the spots of origin are of a "dark" colour, either distinctly brown, or approaching black.

The colours of the tentacles have not been separately tabulated. Usually the ends (distal branches) are darker than the stalks and show the general colour of the body. The stalks are sometimes whitish, or colourless, or again, more or less of the darker tints of the ends run down upon them.

2. *Distribution of Colour on the Body.*

In Table VIII. it is shown that 12 °/₀ of the adult and only 4 °/₀ of the young are uniformly coloured. In all such cases browns and generally dark tints like seal and clove prevail. The mid-dorsal region is uniform in 60 °/₀ of the adult, and in only 13 °/₀ of the young. Here again are the browns exclusively. When the colours of this region are mixed the dark browns like seal, clove and Vandyke are predominant, with some intermixture of creams and grays, in both the ground-colour and the markings, of the adults. In the young, while the browns of lighter tints prevail in the ground-colour, the creams and especially the grays and white are in excess in the markings.

The lateral-dorsal regions present much more variegation, since only 28 °/₀ of the adult and 6 °/₀ of the young are uniform and there is a decided turning to the lighter browns and creams. When the colours are mixed the browns still predominate in the adult, although the markings are somewhat lighter, while in the young the ground-colour and markings are proportioned about as in the mid-dorsal with some increase of the creams.

The ventral region in the adult shows a return to greater uniformity (57·5 °/₀) but now the tints are among the lighter browns and the creams, while only 33 °/₀ of the young are uniform, with the browns, creams and grays about evenly represented. When the colours are mixed there is in the adult a decided increase of the creams in the ground-colour with more of the browns in the markings, while for the young in the ground-colour the creams, and especially the grays, increase, and in the markings the browns are equalled by white, each being only one-seventh, while the creams and grays make together five-sevenths, of the colouration.

In the adult the percentage of creams is doubled from mid- to lateral-dorsal and again from lateral-dorsal to ventral, thus gradually changing the colour from the dark brown back to the lighter belly, but even here the browns are predominant. In the young the increase in creams ventral is not so marked but, added to the very large percentage of grays over the whole body, gives the light and variegated colouration which so generally strikingly characterizes the young of *H. floridana* and may lead one upon superficial examination to class such individuals with *H. grisea* Selenka. Pourtalés, 1851, p. 13, noted that the young "are of a lighter colour than the old individuals." Hérouard, 1902, p. 8, describes the colour, at the moment of capture, of one specimen as greenish, dotted with brown spots upon the back, while the ventral surface is uniform, and he describes another as having, in addition to the brown dots, spots more extended and of a lighter brown. Clark, 1901, p. 258, notes great variation in colour.

In general in both adult and young, as graphically represented in Plates I. and

II. a, the ground-colour is marked with dots, spots, blotches, streaks, or more rarely rings, of different tints. Altogether the rings occur 37 times, 28 being in the browns and 9 in the creams. The party-coloured coats of these Holothurids are often very beautiful and sometimes present most fantastic combinations of nearly all the possible tints and shades of the browns, creams, and grays from black to white.

D. Tentacles and Ampullae.

Because of the great contraction of the anterior end of the body and of the retracted tentacles one is liable to make errors in counting tentacles even with the exercise of considerable care. After the first determinations, in working out the relation of these organs to the symmetry and the correlation of tentacles and ampullae, the various parts were spread out. In many cases a seeker was passed from ampulla to tentacle and in others Prussian blue was injected, either through the radial canal, or the ampulla. Thus, in several specimens, it was found that, in the previous count, short stumps of tentacles had been overlooked.

a. Symmetry in Arrangement of Tentacles and Ampullae.

Normally there are 20 tentacles arising from the radial canals and distributed evenly in the interradii as shown in Fig. A. See Plate V.

Fig. A, represents the scheme for the symmetry in the arrangement of the tentacles, tentacle ampullae, dorsal mesentery, and calcareous ring.

A dotted line indicates the median plane passing through the mid-ventral radius, the mid-dorsal interradius, and the attachment of the dorsal mesentery to the mid-dorsal interradiale. MVR, mid-ventral radius; RVR, right ventral radius; LVR, left ventral radius; RDR, right dorsal radius, LDR, left dorsal radius, *d*1, *d*2, the tentacles dorsal, and *v*1, *v*2, ventral, *r*1, *r*2 right, and *l*1, *l*2 left, of the radius marked; OC, oral canal; OE, oesophagus; RC, radial canal; T, tentacle; TC, tentacle canal; TA, tentacle ampulla; R, radiale; IR, interradiale.

Variations from the Symmetry of the Tentacles of the Mid-Dorsal Interradius in Relation to the Attachment of the Mesentery.

The simplest pattern in asymmetry is where the number of tentacles is normal, and among those for the dorsal interradius one more than usual is found on one side or the other of the mesentery. Including this kind of asymmetry found in individuals having at the same time more or less than the normal number of tentacles, there are, in all, 27 cases in which the tentacles of the dorsal interradius are distributed as follows:—

Number of Cases	To Right of Mesentery	To Left of Mesentery
12	3	1
8	1	3
1	3	2
4	1	2
1	4	1
1	1	4

The mesentery is attached at the junction of the dorsal interradiale with the left dorsal radiale in 10 cases (15, 28, 35, 41, 45, 66, 68, 70, 73, 89) and with the right dorsal radiale in 1 (98); to the left side of the dorsal interradiale in 33, 37, and to the right side in 34; slightly to the left of the mid-line in 19, 20, 77, and to the right of the mid-line in 113. The attachment is very broad for about 1 cm. in 40. In 37 the dorsal interradiale is fused with the right dorsal radiale. One would anticipate that the displacement of the tentacles should be in the opposite direction to the displacement of the mesentery found in 14 of the above cases. Such a relation indeed is present in 11 of the 14 specimens. While the mean, in adult and young, is about the same, there is greater range and greater variability in the adult than in the young.

b. NUMBER OF TENTACLES.

TABLE IX.

	Adult	Young
Number of Specimens ...	73	45
Mean	19·709 ± ·064	19·756 ± ·064
Standard Deviation ...	·808 ± ·045	·642 ± ·025
Coefficient of Variation ...	4·099 ± ·229	3·229 ± ·229
Range of Variation ...	16—22	18—21

Variation in the Number of Tentacles and the Relation of those Present to the Normal Symmetry.

Adult and young are tabulated separately but under this particular head they are treated as one group. Among the 30 varieties there is a decided tendency to reduction in the number of tentacles, since 23 individuals (76·6 %) have less than the norm of 20 tentacles. It is well known that holothurians may lose one or more tentacles by accident, hence this excess in individuals with less than the norm probably represents such losses rather than congenital variation. This interpretation is also justified by the fact that in many cases of deficiency of tentacles the normal number, 20, of ampullae, is present.

Of the 12 cases in the 19 tentacle class, 9 (75 %) have the tentacle absent in the trivium. Of the 10 cases in the 18 tentacle class, 3 lack the 2 tentacles in the trivium, 1 in the bivium, 4 lack 1 tentacle in each region and 2 are not determinable. Of the 23 cases in all, 15 (65 %) have the tentacle deficiency in the trivium.

Holothurid 5 with 16 tentacles, lacks the 4 of the left ventral interradius, *v*2, *v*1 from the left ventral radius and *l*2, *l*1 from the mid-ventral radius. In the

TABLE X.

Variations with less than 20 *Tentacles.*

Distribution in accord with the scheme of symmetry given in Fig. A (Plate V.).
Absence of tentacles in particular radius indicated by 0.

Age	Serial Number	Right Dorsal				Left Dorsal				Right Ventral				Left Ventral				Mid-Ventral				Total Number
		d1	*d2*	*v2*	*v1*	*d1*	*d2*	*v2*	*v1*	*d1*	*d2*	*v2*	*v1*	*d1*	*d2*	*v2*	*v1*	*l1*	*l2*	*r2*	*r1*	
Adult	*1*	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	19
	35	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	19
	37	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	19
	41	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	19
	52	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	19
	55	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19
	57	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	19
	66	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	19
	6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18*
	20	—	—	—	—	—	—	—	—	—	—	0	—	—	—	0	—	—	—	—	—	18
	28	—	—	—	—	—	—	0	—	—	0	—	—	—	—	—	—	—	—	—	—	18
	40	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	0	—	18
	45	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	0	—	—	18
	63	—	—	—	—	—	0	0	—	—	—	—	—	—	—	—	—	—	—	—	—	18
	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	0	0	—	—	16
Young	*88*	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	19
	97	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	19
	102	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19
	111	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	19
	77	—	0	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	18
	80	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	0	—	18
	82	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18†
	89	—	—	—	—	—	—	—	—	—	0	—	—	—	—	0	—	—	—	—	—	18

* Tentacles lost before exact distribution was noted.

† Specimen very small and too mutilated for determination of distribution.

calcareous ring of this specimen (Fig. 96) the ventral and left ventral radialia are fused, the intervening left ventral interradiale being included in the composite piece.

TABLE XI.

Variations with more than 20 *Tentacles.*

Distribution in accord with the scheme of symmetry in Fig. A. Presence of extra tentacle in particular radius given.

Age	Serial Number	Right Dorsal	Left Dorsal	Right Ventral	Left Ventral	Mid-Ventral	Total Number
Adult	*30*	*d*3	—	—	—	—	21
	61	—	—	*d*3	—	—	21
	62	*d*3	—	—	—	—	21
	73	—	*v*3	—	—	—	21
	19	—	—	—	*d*3, *v*3	—	22
	34	—	—	*d*3	*v*3	—	22
Young	*113*	—	*d*3	—	—	—	21

In the 7 cases with more than the normal 20 tentacles there appears a slight tendency to the addition of extra tentacles dorsally.

c. Branches on Tentacle Ampullae and Variation in their Number.

TABLE XII.

Branches on Tentacle Ampullae.

Distribution as in Fig. A. Number of branches in :—

Serial Number	Right Dorsal	Left Dorsal	Right Ventral	Left Ventral	Mid-Ventral	Total Number
1	—	*v*1 (2)	—	*v*1 (1)	—	3
2	—	*v*1 (1)	—	—	—	1
3	—	—	—	—	*l*1 (2)	2
7	*d*1 (7)	*d*1 (1) *v*2 (3) *v*1 (2)	—	*d*1 (7) *d*2 (3)	—	23
8	—	*v*2 (1)	—	—	—	1
10	*d*2 (1)	—	—	—	—	1
11	*d*2 (1)	—	—	—	—	1
15	*v*2 (1)	—	—	—	—	1
16	—	—	*d*2 (1)	—	—	1
30	—	—	—	—	*r*1 (1)	1
32	*v*1 (1)	—	—	—	—	1
33	—	*v*1 (1)	*v*1 (1)	—	—	2
35	—	—	*v*1 (2)	—	—	2
57	*d*1 (1)	—	—	—	—	1
63	*v*1 (1)	*d*2 (1)	—	—	—	2
67	—	*v*2 (1)	—	—	—	1
70	—	*v*1 (3)	—	—	—	3
73	—	*d*1 (1)	*d*1 (1)	—	—	2

In 18 individuals of Table XII. 27 of the tentacles have ampullae with branches. Of these, with origin as given in the Table, 18 have 1, 4 have 2, 3 have 3, and 2 have 7 branches.

In 16, *d*1 right dorsal radius arises under the mesentery, slightly toward the left and then passes over to the right. In 63, *d*1 right dorsal radius arises to the right of the mesentery and then passes beneath the mesentery to the left.

The ampullae of 7 are rather remarkable in having altogether 23 branches and in that 2 (*d*1, right dorsal radius and *d*1, left ventral radius) have each 7 branches in the form of a tuft. The branches are found only in adults and so indicate one of the changes which may come with advancing age.

d. Variation in Size of Tentacles.

Variations from the normal size of the tentacle may be classed as *small* and *medium*. The number of small tentacles present in Holothurids of my series are found to vary from 2 in 42, 60, 93, 95, 96 and 3 in 18, 108 to 5 in 33 and 6 in 7. In addition to the 6 in the last case there are 4 tentacles of medium size. A stump of a tentacle, lost by accident, is present in 1, 56 and 58 and 2 such stumps in 42. In most cases it is probable that small and medium sizes are stages in regeneration from the stumps of those lost by accident although, of course, it is possible that they are congenital variations in size.

e. Development of Tentacles.

The completed study of the development of the ambulacral appendages necessitates some minor changes from my preliminary report (1907). The first 4 tentacles are found on the 4th day, when the embryo is still within the vitelline membrane. Represented in accord with Fig. A, Pl. V. the 4 tentacles arise from the radial canals as follows:—*d*1, left dorsal; *d*1, right ventral; *r*1, mid-ventral and *d*1, left ventral. The 5th, *l*1, mid-ventral, buds on the 4th day and thus completes the primitive symmetry. The 6th, *d*2, right ventral, has developed by the 40th day. From the 40th to the 49th days appear the 7th, *d*2, left ventral, the 8th, *d*1, right dorsal and the 9th and 10th, *v*1, of either right, or left, dorsal. If the 9th arises from the right, then the 10th comes from the left, dorsal, or *vice versa*. The 11th, *r*2, mid-ventral, buds on the 49th day. The 12th, *l*2, mid-ventral, appears on the 71st day, and the 13th, the last in my series raised from the embryo, is *d*2, left dorsal, and is developed by the 75th day.

E. Pedicels and Papillae.

It is often very difficult to differentiate papillae from pedicels both as regards their form and the presence, or absence, of calcareous end-plates (cf. Ludwig, 1889–92, pp. 100—110; Lampert, 1889, p. 821 and 1896, p. 53). The whole

matter is of such interest and importance in the solution of the problems presented by the thesis of this paper that I have taken up the various elements in detail.

TABLE XIII.

a. DISTRIBUTION PER SQ. CM.

Directly counted through an opening of 1 sq. cm. punched in a metal sheet. When the animal is sufficiently large an opening of 4 sq. cm. is used and the average sq. cm. obtained. On very small individuals the appendages are in distinct rows and an exact average per sq. cm. is impossible but the nearest number is given, although often obtained from a fraction of one sq. cm. and multiplied to the standard for comparison. In one case, 104, the smallest young individual, this leads to an error, for it is credited with 44 dorsal appendages per sq. cm., when a count shows only 12 present in the dorsal region.

	Dorsal		Ventral	
	Adult	Young	Adult	Young
Number of Specimens ...	73	45	73	45
Mean	13·096 ± ·279	20·667 ± ·876	25·288 ± ·675	35·112 ± 1·432
Standard Deviation ...	3·545 ± ·197	8·717 ± ·620	8·550 ± ·477	20·147 ± 1·432
Coefficient of Variation ...	26·994 ± 1·507	42·175 ± 3·000	33·819 ± 1·867	57·379 ± 4·179
Range of Variation ...	6—22	8—44	6—50	11—128

The above table shows that there are 1·6 as many appendages in the trivium as in the bivium in the adult, and 1·4 as many in the young, and that the young have a considerably greater standard deviation in both regions. There is a wide range of variation in the adult as well as in the young, and thus in some individuals the appendages are scattered while in others they are closely crowded. The number per sq. cm. may vary more or less with the state of contraction of the specimens. The absolute number for the whole body in very small individuals is much less than in large ones, yet the number per sq. cm. may be relatively very large as in 77 which is 4·4 cm. long and has 128 ventral appendages per sq. cm. while the largest number found in any adult is 50 per sq. cm. in 23, which is 12 cm. long. Ordinarily the smaller number of appendages per sq. cm. in the adult demonstrates that the increase in number of appendages does not keep pace with the general growth of the body-wall.

In 5 specimens the papillae, as defined on p. 267, were counted, yielding an average of ·86 per sq. cm. *In other words about* 1 *out of* 16 *of the dorsal appendages is a papilla.*

b. DEVELOPMENT AND APPEARANCE.

The first pedicel is present as a bud from the posterior end of the mid-ventral radius of the 4th day embryo. The 2nd buds on the 7th day, the 3rd, on the

22nd day, and the 4th on the 33rd day, all 3 from, and *to the left of*, the mid-ventral radius. On the 24th day the 1st pair of papillae bud ventral from the anterior ends of the dorsal radii and will become the first of the *warts* described below. On the 30th day the first pair of pedicels appear from the lateral-ventral radial canals, one on each side. Not before the 40th day does there appear a pedicel from the mid-ventral radius *to the right*. Gradually the number of ambulacral appendages increases until on the 75th day there are 30 developed pedicels and papillae and 68 buds, mostly arranged in rows along the radial canals.

In the adult this arrangement in radial rows is obscured by the presence of fairly evenly distributed interradial appendages. The smaller young individuals, as Pourtalés, 1851, p. 12, remarks, show the radial rows more distinctly. In 3 of the smallest of the young of my statistical series the appendages were counted with the following result:—

Serial Number	Volume c.c.	Mid-Ventral Radius	Right Ventral Radius	Left Ventral Radius	Right Dorsal Radius	Left Dorsal Radius	Inter-radial in Dorsal Region	Totals
104	·26	22	21	22	6	6	—	77
103	·46	23	23	22	10	9	12	99
105	1·00	30	30	30	12	12	36	150

c. Warts.

Pourtalés, 1851, p. 12, noted that of the dorsal papillae the two rows situated near to the ventral surface, are always very conspicuous. "They are erectile, like the suckers, and possess a canal, which communicates with an internal vesicle." I have adopted the name *warts* for the more or less prominent conical projections usually formed from an accumulation of rosettes, perforated plates and their developmental stages. The warts nearly always bear a papilla; occasionally more than one. They appear along the sides, having arisen from the right and left dorsal radii or sometimes they are scattered over the back. Being made of spicules, the warts are of light colour and generally stand out against the darker background. Where warts are not noted it is probable that some are present but obscured by an increased number of spicules in the skin, or by dark colour.

TABLE XIV.

1. *Distribution of Warts.*

	Right and Left	Right Only	Left Only	Scattered on Bivium	Traces	None	Totals
Adult ...	20	—	—	1	25	27	73
Young ...	35	1	2	1	5	1	45

These warts are much more prominent in the young for 97⅞ °/₀ of this class show warts or their traces, as against 63 °/₀ of the adult. Of those with warts, 80 °/₀ of the young have them in the prominent right and left lateral rows, while this is true in only 27 °/₀ of the adult.

TABLE XV.

2. *Number of Warts on Sides of Bivium.*

	Adult		Young	
	Right	Left	Right	Left
Mean	9·25	8·65	7·90	7·68
Range of Variation ...	5—15	5—19	1—14	3—12

d. PAPILLAE AROUND THE ANUS.

Selenka, 1867, p. 325, mentioned a crown of papillae surrounding the anus, and Théel, 1886, p. 216, described a specimen of *H. mexicana* Ludwig, as having the "anus with five minute groups of papillae."

TABLE XVI.

Distribution of Papillae around the Anus.

Age	In Groups							In a Circle	Indefinite	Destroyed	Totals
	Number of Groups										
	0	*1*	*2*	*3*	*4*	*5*	*6*				
Adult ...	1	0	1	1	8	44	1	4	12	1	73
Young ...	1	0	0	1	4	31	1	7	—	—	45

From Table XVI. it is seen that in 60·4 °/₀ of the adult and 68·8 °/₀ of the young there are 5 groups of papillae around the anus. These groups may run into one another but their centres are always clearly marked. The anal papillae vary in length from ·1 to 1·5 mm. and have the supporting rods characteristic of papillae in general.

F. Thickness of Body-wall.

The much larger mean and range of the adult show, as one would naturally expect, that the body-wall (skin) becomes thicker with age. Not only is the adult body-wall nearly three times as thick as the young, but at the same time the standard deviation is nearly three times as much.

TABLE XVII.

Determined by measuring in mm. the thickest and thinnest places along a ventral incision and then taking the average.

	Adult	Young
Number of Specimens ...	62	44
Mean	4·144 ± ·195	1·495 ± ·084
Standard Deviation ...	2·274 ± ·138	·827 ± ·059
Coefficient of Variation ...	54·876 ± ·332	5·527 ± ·397
Range of Variation ...	1·0—13·0	·1—3·0

Naturally some individuals will die with the body-wall much more contracted than the average, and others with it much more expanded. Thus in 56 the body-wall is quite uniformly "thin" (·3 mm.—1·0 mm. thick) and in this one character the specimen is similar to *H. atra*.

G. Calcareous Spicules of the Body-wall.

These spicules are of three classes; tables, rosettes and perforated plates. They are not always distributed evenly throughout the body-wall but often in heaps and groups, which in some cases may be due to greater contraction in the regions where they occur. In general the spicules are more numerous in the trivium. At least in the young the spicules are being developed constantly, so that a more or less complete series of stages illustrating their development may be secured. The data were obtained from pieces of the body-wall of 2 or 3 sq. cm. area taken from near the middle of the body, cleared in dilute potassium hydras and then, after dehydration by the alcohols, mounted from cedar oil into balsam.

a. Tables.

The tables in *H. floridana* are like those of *H. atra* and so in the following general description of their development, structure and variation no attempt is made to keep separate account of *H. floridana* and *H. atra* specimens. The tables studied did not lie near any appendage and so unquestionably belong to the body-wall. They are found in the superficial layer of the dermis.

1. *Development of the Table.*

The developmental series represented by Pl. IV., Figs. 42—49, was selected from many individuals during the progress of this study. As shown by Düben and Koren, 1844, this spicule begins as a cross-shaped body or as better expressed by Ludwig, 1889–92, pp. 45, 56, as a short rod with forked ends (Fig. 42). At the proximal end of each prong a vertical rod arises (Figs. 43, 44). The end of each

prong forks (Fig. 45, a variate with 5 prongs and 5 vertical rods), and these branches grow toward one another while the vertical rods rise higher and the centre of the fundamental rod becomes elevated (Fig. 46). The outer branches grow together and unite to form the primary and peripheral holes of the disc, while the distal ends of the vertical rods are joined by transverse beams to build the crown, and then the teeth begin to appear (Fig. 47). Finally the last cross-beam is added to complete the crown and spire, the last peripheral branches fuse to form the disc, the teeth enlarge and the normal table is completed (Figs. 48, 49).

2. *Structure of the Table.*

The typical table consists of a disc perforated by 4 larger, primary holes extending toward the centre alternating with 4 secondary holes of medium size in the periphery (Figs. 49, 64—97). Generally there are one or more (range 1—9) smaller tertiary holes in between the secondary and forming with them a peripheral circle (Figs. 57—62). The bars between the primary holes bend upward, so that the centre of the disc is elevated, and at the same time it supports a spire consisting of 4 vertical rods united distally by cross-beams to form a crown (Fig. 49). The crown bears at each of its 4 corners, 3 teeth; 2 horizontal, diverging at right angles, each continuing the axis of a cross-beam, and the 3rd perpendicular to the plane of the others (Fig. 75, the positions of the underlying vertical rods shown by dotted circles).

3. *Variation in Crown and Vertical Rods.*

Among the 234 tables of *H. floridana* 5 have a triangular crown (Fig. 79) supported by 3 vertical rods; 5 have the crown arrested in development, the central hole not formed and with only 3 vertical rods (Fig. 80), and 4 have the normal 4 vertical rods but with the crown incomplete on one side. Three have spires with 5 vertical rods.

The number of teeth varies from 6 to 16, the largest number being represented in Fig. 78. Sometimes odd teeth project from the middle of the cross-bars (Figs. 76, 77, 83). There are 5 crowns in each of which 1 tooth is bifid at the tip; 2 crowns with 2 teeth bifid; 1 crown with 6 teeth bifid; 1 crown with 7 teeth bifid and 1 crown with 1 tooth trifid.

Not included in the statistical series of *H. floridana* are several interesting variations. Fig. 81 shows a triangular crown without a central hole; Fig. 82, a partly formed crown hole; Fig. 86, an incomplete crown with 3 teeth bifid and 5 supporting rods; Fig. 87, a complete disc with 5 rods and no crown; Fig. 88, the disc, and Fig. 89, the crown, of a table with 7 rods; Fig. 90, from above and Fig. 91 from below, a depressed abnormal form.

b. Tables of Bivium and Trivium in *H. Floridana*.

For the study of these tables data were taken from 14 Holothurids representing various places scattered over the Florida-Caribbean region. When possible the

measurements and counts were made from 10 tables in the bivium and 10 in the trivium of each specimen. Without attempting a study of the variation in the different parts of the table in individual Holothurids, the determinations for the species were made from the whole 130 dorsal and 104 ventral tables.

TABLE XVIII.

Tables of Bivium and Trivium.

		Disc				Crown			
		Number of Peripheral Holes	Number of Spines	Diameter μ	Height μ	Number of Teeth	Diameter of Hole μ	Diameter not including Teeth μ	Diameter including Teeth μ
Dorsal	Mean	5·746 ± ·149	·907 ± ·091	50·210 ± ·351	54·150 ± ·529	12·177 ± ·064	7·220 ± ·140	18·720 ± ·150	38·590 ± ·106
	Standard Deviation	2·523 ± ·106	1·883 ± ·079	5·940 ± ·248	8·945 ± ·374	1·078 ± ·045	2·340 ± ·088	2·534 ± ·158	5·176 ± ·217
	Coefficient of Variation	43·909 ±1·837	199·21 ± ·833	11·839 ± ·490	16·510 ± ·690	8·849 ± ·370	32·41 ±1·36	13·510 ± ·570	13·420 ± ·570
	Range of Variation	0—13	0—10	35·2—67·2	32·3—72·6	8—16	3·2—12·8	12·8—22·4	25·6—54·4
Ventral	Mean	4·654 ± ·144	·346 ± ·075	42·539 ± ·524	45·610 ± ·660	11·692 ± ·092	6·560 ± ·013	18·750 ± ·241	35·904 ± ·388
	Standard Deviation	2·170 ± ·091	1·150 ± ·044	5·342 ± ·140	9·934 ± ·465	1·394 ± ·065	1·920 ± ·092	2·400 ± ·115	6·012 ± ·281
	Coefficient of Variation	46·617 ±2·180	332·29 ±1·554	12·550 ± ·590	21·770 ±1·020	11·923 ± ·558	29·260 ±1·400	12·800 ± ·610	16·740 ± ·780
	Range of Variation	0—10	1—6	32·0—57·6	24·3—81·0	6—14	0—9·6	9·6—22·4	22·4—51·2

1. *Disc.*

The form of the disc has the following distributions: *dorsal*;—square, 81 (62·3 °/₀) (Pl. IV. Figs. 54 and 66); irregularly square, 8 (6·2 °/₀) (Figs. 53 and 73); round, 7 (5·4 °/₀) (Figs. 60 and 72); irregularly round, 12 (9·2 °/₀) (Figs. 62 and 74); irregular, 22 (16·9 °/₀) (Figs. 52, 55 and 70): *ventral*;—square, 58 (55·8 °/₀); irregularly square, 14 (13·5 °/₀); round, 3 (2·8 °/₀); irregularly round, 13 (12·5 °/₀); irregular, 16 (15·3 °/₀). These types run into one another, and when the irregular variations are added to their respective types the form of the disc is practically the same in both bivium and trivium.

The mean number of peripheral holes in the disc, in the dorsal tables, is 6*, with a range of 0—13; in the ventral, 5 with a range of 0—10 (Figs. 49—74). In the series of variates there is a typically symmetrical form with 4 secondary holes (Figs. 54, 64—67), one at the base of each vertical rod (Fig. 49). When

* In the discussion of the tables the nearest whole numbers are used.

more than the 4 secondary peripheral holes are present, the additional tertiary ones are usually smaller (Fig. 61). It is to be noted that an asymmetrical distribution of peripheral holes prevails.

The mean number of spines on the disc is ·9 in the dorsal tables with a range of 0—10 and ·3 in the ventral, with a range of 0—6. With the mean less than 1 it is apparent that spines are not often found in any number. Sometimes the spines are large (Fig. 69), and again they may arise from a projection of some size (Fig. 68). Of the dorsal tables 22 °/₀ bear spines while only 11 °/₀ of the ventral are so characterized, and thus the possession of spines cannot be considered normal in the species. Hence, as a diagnostic character of Semper's discarded variety *amboinensis*, the possession of spines on the disc has no significance.

The mean diameter of the disc is 50 μ in the dorsal tables, with a range of 35 μ—67 μ, and 43 μ in the ventral, with a range of 32 μ—58 μ.

2. *Height.*

The dorsal tables have a mean height of 54 μ, with a range of 32 μ—72 μ; the ventral 45 μ, with a range of 24 μ—81 μ, and thus the dorsal tables are 20 °/₀ higher than the ventral.

3. *Crown.*

The mean number of teeth is 12 in the dorsal tables, with a range of 8—16, and 12 in the ventral, with a range of 6—14.

The mean diameter of the hole is 7 μ in the dorsal crowns, with a range of 3 μ—13 μ; 7 μ in the ventral, with a range of 0 μ—10 μ. In Fig. 76 this hole is large; in Fig. 79, small, while in some cases it is absent (Fig. 81).

The mean diameter of the crown, not including teeth, is 19 μ in the dorsal tables, with a range of 13 μ—22 μ; 19 μ in the ventral, with a range of 10 μ—22 μ; the diameter of the crown including teeth 39 μ in the dorsal tables with a range of 26 μ—54 μ; 36 μ in the ventral, with a range of 22 μ—51 μ. Taking one half of the difference between the two last determinations, the average length of the teeth on the crown is 10 μ in the bivium and 9 μ in the trivium.

Thus from an examination of Table XVIII. it is found that the dorsal tables have more peripheral holes, spines and teeth, broader crown, larger crown-hole and longer teeth than the ventral tables, albeit the difference in some of these characters is very small. As shown by the standard deviations, the features of the disc are more variable in the dorsal tables, while the height and crown characters are more variable in the ventral tables.

In the suckers of the dorsal pedicels are found what may be called reduced tables, in which only that central part of the disc immediately below and supporting the well-developed spire is present (Fig. 92).

c. Rosettes and Rosettes with Holes.

Generally the rosettes are stellate of 3 or 4 broad rays, forked and rounded at the swollen ends (Figs. 29—31). Sometimes the central part is drawn out so that the spicule is irregularly H-shaped (Fig. 28), and then from this central bar additional projection may arise (Fig. 32). When some of the prongs of the forked ends grow together and fuse, the spicule comes under the class of rosettes with holes (Fig. 33). The average thickness of the rosette is 5 μ but often the centre is still thicker (10 μ), giving a biconvex contour to the spicule as seen in profile. These spicules lie in the dermis below the tables. They may be few and scattered but are, for the most part, densely crowded together in heaps, often of irregular outline, or less frequently in rings.

The determinations recorded in Table XIX. were taken from 10 specimens of *H. floridana*, 15 spicules from the dorsal region and 15 from the ventral, of each Holothurid, or from a total frequency of 150 dorsal and 150 ventral rosettes and rosettes with holes.

In the bivium there are 141 (94 °/₀) rosettes and 9 (6 °/₀) rosettes with holes, and in the trivium 133 (89 °/₀) rosettes and 17 (11 °/₀) rosettes with holes.

TABLE XIX.

Rosettes and Rosettes with Holes.

		Rosettes		Rosettes with Holes		
		Greater Diameter μ	Smaller Diameter μ	Number of Holes	Greater Diameter μ	Smaller Diameter μ
Dorsal	Mean	22·030 ± ·221	18·090 ± ·173	2·556 ± ·321	26·800 ± ·509	21·470 ± ·449
	Standard Deviation ...	3·903 ± ·157	3·056 ± ·123	1·427 ± ·228	2·265 ± ·356	1·996 ± ·317
	Coefficient of Variation	17·700 ± ·710	16·910 ± ·680	55·829 ±8·876	8·430 ±1·340	9·320 ±1·480
	Range of Variation ...	14·4—28·8	9·6—24·0	1—5	24·0—28·8	19·2—24·0
Ventral	Mean	20·470 ± ·223	17·010 ± ·161	3·353 ± ·258	27·450 ± ·768	21·530 ± ·506
	Standard Deviation ...	3·814 ± ·158	2·748 ± ·114	1·577 ± ·183	4·693 ± ·543	3·093 ± ·358
	Coefficient of Variation	18·610 ± ·770	16·110 ± ·670	47·037 ±5·441	17·080 ±1·970	14·350 ±1·660
	Range of Variation ...	9·6—28·8	9·6—24·0	1—6	19·2—33·6	14·4—24·0

In the bivium the mean dimensions of the rosettes are 22 μ × 18 μ and of the rosettes with holes, 27 μ × 21 μ; in the trivium the rosettes are 20 μ × 17 μ and

the rosettes with holes, $27\mu \times 22\mu$. The increased size of the rosettes with holes shows that they are older, and it is probable that most of them are developmental stages of the perforated plates.

Comparing the rosettes in the bivium and trivium, it is seen that the mean number of holes in the former is less than 3 and in the latter more than 3. Corresponding to this increase in the mean number of holes, the greater diameter of the ventral rosettes with holes is 16 °/₀ above that of the dorsal, while at the same time the standard deviations show that the size of these ventral rosettes is more variable and they have a greater range. Pourtalés, 1851, referred to the rosettes when he noted (p. 12) that "the skin contains small, calcareous bodies, of various forms, but mostly in that of an irregular cross, or star, the branches of which are bifurcated at their extremity."

d. PERFORATED PLATES.

The determinations in Table XX. were made from 10 Holothurids, taking 15 plates in the bivium and 15 in the trivium of each, thus giving a total frequency of 150 dorsal and 150 ventral plates. In general the plates are more numerous ventrally than dorsally.

TABLE XX.

Perforated Plates.

		Dorsal			Ventral		
		Number of Holes	Length μ	Width μ	Number of Holes	Length μ	Width μ
Developmental Stages	Mean	6·420 ± ·128	28·840 ± ·204	22·870 ± ·262	6·515 ± ·181	26·510 ± ·445	21·130 ± ·314
	Standard Deviation ...	1·539 ± ·090	2·461 ± ·144	3·155 ± ·190	1·540 ± ·128	3·787 ± ·314	2·673 ± ·222
	Coefficient of Variation	23·793 ±1·397	8·530 ± ·506	13·810 ± ·810	23·634 ±1·962	14·290 ±1·190	12·630 ±1·050
	Range of Variation ...	2—8	19·2—38·4	14·4 –28·8	4—8	19·2—33·6	14·4—24·0
Developed	Mean	13·476 ± ·216	29·040 ± ·207	23·710 ± ·192	14·761 ± ·244	26·690 ± ·212	22·460 ± ·170
	Standard Deviation ...	2·932 ± ·153	2·819 ± ·147	2·603 ± ·140	3·915 ± ·173	3·402 ± ·151	2·723 ± ·120
	Coefficient of Variation	21·754 ±1·132	9·710 ± ·513	10·960 ± ·566	26·523 ±1·170	12·730 ± ·560	12·110 ± ·530
	Range of Variation ...	9—21	24·0—38·4	19·2—28·8	9—31	19·2—38·4	19·2—33·6

1. *Development of the Perforated Plate.*

The plate begins as a rod with forked ends, the simple rosette, like Pl. IV. Fig. 28, of the same fundamental form (cf. Ludwig, 1889–92, p. 58) as the 'Anlage'

of the table (Fig. 42) but with the central rod shorter and more slender and the prongs shorter, wider and thicker. The diverging branches of the prongs unite to form holes and thus is developed the 4-holed symmetrical *Type a* (Fig. 37) in which the 2 central holes are about twice the size of the 2 terminal holes. Of this type there are 2 °/₀ dorsally and 6 °/₀ ventrally. Plates of this stage in general have not the perfectly smooth contour of Fig. 37 but show one or more bifurcating branches which will unite to make 2 additional holes at each end and thus produce the 8-holed symmetrical *Type b* (Fig. 38). Eighteen per cent. of both the dorsal and ventral developmental stages are of *Type b*. The majority of *Type b* plates have the peripheral prongs indicating growth toward the complete plate, and also bars running into the larger central holes, as well as occasionally into the smaller holes (Fig. 38 a).

*Type a** with 4 holes asymmetrically distributed does not occur in the dorsal series but does in 6 °/₀ of the ventral, and *Type b** with 8 holes asymmetrically distributed is found in 5 °/₀ of the dorsal and 15 °/₀ of the ventral. *Type c* includes all of the plates with 5—8 holes indefinitely distributed, part of them showing the regular contour which might be taken to indicate a fully developed plate, and part of them with the prongs of growth of an incomplete plate. *Type c* constitutes 76 °/₀ of the dorsal and 55 °/₀ of the ventral plates. It is quite possible that many of these types, especially those with regular contours and of large size, are developed plates ("buttons"), but since *Types a* and *b* are clearly two well-marked developmental stages, I have included all plates with 8 or less holes in the same general group of perforated plates in the process of development. Their mean number of holes is about 6·5 both dorsally and ventrally, their mean dimensions $29\mu \times 23\mu$ dorsally and $27\mu \times 21\mu$ ventrally with practically no difference in the standard deviations in the two regions.

2. *Structure and Variation of the Developed Perforated Plates.*

The plate becomes developed by the addition of more holes to *Type b*, while, with increasing age all of the holes may be gradually filled in with lime (Figs. 39, 40, 41). The mean number of holes is 13 dorsally and 15 ventrally and the mean dimensions $29\mu \times 24\mu$ dorsally and $27\mu \times 22\mu$ ventrally, with the standard deviations somewhat greater in the ventral region.

20 °/₀ of the dorsal and 10 °/₀ of the ventral plates have the peripheral projections which indicate that additional holes may be in process of formation. Such a plate, much larger than the average, is shown in Fig. 34. In many cases a bar, or sometimes 2 or 3 may grow out into each of the 2 primary central holes (Fig. 34). The bar may grow through the hole, fusing with the opposite wall, and thus forming 2 holes in place of the normal single hole.

In the majority of these developed plates it is easy to trace the fundamental *Type b* (cf. Pl. VIII. Fig. 7, d, e of *H. africana* Théel, 1886).

Sometimes the initial forked bar is much thicker than usual (Fig. 35) and after the fusion of the terminal branches the 2 primary holes formed are very

small (Fig. 36). With age the holes may become so much filled in with calcareous matter as to assume the form of pits (Fig. 41, where 11 of the 15 holes have become pits; indicated by the cross lines). Upon some of the plates are ridges and then the holes lie in the furrows between the ridges. The standard deviations given in Table XX. show that the developed plates are more variable than the undeveloped.

A specimen from Key West, Florida, compared with specimens from Porto Rico and St Thomas, presents plates with more holes and at the same time has more plates with developmental branches which indicate that yet additional holes will be formed. An extended study of the perforated plates from the various localities would, without doubt, reveal interesting place modes.

Théel, 1886, p. 215 (cf. also Clark, 1901, p. 258) in describing *H. mexicana* notes that "of the crowded plates two types may be observed, one more rounded, pierced with minute and commonly more numerous holes; and the other irregularly rectangular, with fewer and larger holes." The first of the two types of these authors I consider identical with the developed plate, and the second with the developmental stage *Type b* described in this paper. Ludwig, 1874, in his original description of *H. mexicana* only mentions "numerous symmetrical perforated plates" but figures the two kinds (Taf. VII. Fig. 47 a). These facts, together with the other points in agreement, establish my claim that *H. mexicana* Ludwig and *H. africana* Théel are identical with *H. floridana* Pourtalés, and therefore synonymous with the last-named species.

e. Number of Rosettes and Perforated Plates.

In a piece of the body-wall of 1 sq. cm. area, the average thickness of the layer of spicules, extending through about $\frac{1}{4}$ of the body-wall, was ·82 mm. The spicules averaged ·04 mm. long × ·036 mm. wide × ·005 mm. thick, giving a possible 145,000 spicules in 1 cu.mm., or 11,890,000 to 82 cu.mm., or 1 sq.cm. of surface. The spicules are packed densely in this layer, but a discount must be made for gaps as well as protoplasmic structures between the spicules. Even allowing this to be 50%, there would be still over 5,000,000 spicules to a sq.cm. of surface in the crowded areas.

f. Correlation of Rosettes and Perforated Plates with Advancing Age.

In order to determine whether the different classes of spicules are correlated with special ages of the Holothurid, 62 from the whole series of 118 specimens were carefully examined without, however, any attempt at a quantitative determination. Hence the percentages given below are only approximate. A specimen usually shows a large majority of either rosettes or perforated plates but, at the same time, in each individual some examples, at least, of all classes of spicules occur, illustrating more or less completely the developmental series from the simple rod and x-formed rosette to the complete perforated plate.

The rosettes are specially abundant and thus characterize specimens 18, 26, 42, 47, 52, 53, 71, 75, 78, 80—86, 93, 95, 106, 113—118, twenty-five in all, of which eighteen, or 72 °/₀, are young as judged by the criterion of size (cf. pp. 239, 243). But of the other seven, four do not much exceed the limit for the young (50 c.c.) and the remaining three are considerably below 209·58 c.c., the average size of the adult. Allowing for a natural variation in which some young are larger than the limit I have assumed, it may be asserted that, for the most part, the rosettes are characteristic of young specimens. The perforated plates characterize 25 specimens, 15, 19, 21—25, 36—38, 51, 54, 55, 57—67, 72, all of which are adult. So without question the perforated plates are characteristic of the adult. Four fully grown specimens 32, 50, 56, 69, have 90 °/₀ perforated plates and 10 °/₀ developmental stages, thus closely approaching the adult state. Holothurid 17, with 90 °/₀ developmental stages and 10 °/₀ perforated plates, and 30, 31, 33, with 90 °/₀ developmental stages and 10 °/₀ rosettes, present such intermediate conditions as would be expected in occasional individuals. Specimens 44, 76, 79, 94, have 90 °/₀ rosettes and 10 °/₀ developmental stages, thus mostly presenting a young condition. Of these four, 44, an adult, has a volume much less than the adult average, while the other three are young but above the average for the young. *In view of these facts it is clear that the large majority of spicules in the young are rosettes and in the adult, perforated plates,* while a number of specimens give the intermediate stages of the developmental series. Some rosettes and developmental stages may be found in any adult and some perforated plates in any young.

Mitsukuri, 1897, discovered that, in *Stichopus japonicus* Selenka, with advancing age the tables gradually degenerate "until in full-grown individuals, there are found nothing but small perforated plates, representing only a small central part of the basal disc and without any trace of the spire." In *H. floridana* I have found correlated with advancing age a succession in the developmental stages of the perforated plate, but not a series of degenerative changes in the tables.

H. Calcareous Spicules of the Ambulacral Appendages and the Differentiation of Pedicels and Papillae.

The differentiation of pedicels and papillae is of primary importance. An exact definition of each of these two classes of ambulacral appendages is much needed. In such definitions the elements to be especially considered are (*a*) Form, (*b*) Suckers, (*c*) End-plates, and (*d*) Supporting Rods, together with the correlation of these elements. The end-plates and supporting rods are additional to the tables, rosettes and perforated plates described above for the body-wall, and found as well in the walls of the pedicels and papillae which are evaginations of the body-wall.

From 9 holothurids 88 dorsal ambulacral appendages were taken, and from 3 other specimens, 50 ventral appendages. In a number of cases certain elements were not sufficiently clearly seen for accurate judgment and so are called "not determinable."

a. FORM.

The typical pedicel is cylindrical (Pl. III. Fig. 2), and the papilla conical (Fig. 1). In this species the form of the 88 appendages of the bivium studied is: cylindrical, 49 (55·7 %); conical, 4 (4·5 %); not determinable, 35 (39·8 %). In the trivium all are cylindrical.

b. SUCKERS.

The presence of a fundamental sucker is the chief and necessary character of the pedicel. In 73 (83 %) of the dorsal appendages the sucker is present, in 2 (2·3 %) rudimentary, in 4 (4·5 %) absent and in 9 (10·2 %) not determinable. In all of the ventral appendages a well-developed sucker is present.

c. END-PLATES.

With but one exception the ambulacral appendage has at least some trace of a perforated plate, or a rosette, as the end-plate. One dorsal case was not determinable. In the pedicel the end-plate is large and located in the base of the sucker (seen in profile in Plate II. Fig. 2).

TABLE XXI.

Diameter of End-plates in μ.

	Dorsal				Ventral		
	Type				Type		
	A	*B*	*C*	*D*	*A*	*B*	*C*
Frequency	41 (47·7 %)	36 (41·9 %)	8 (9·3 %)	1 (1·1 %)	46 (92 %)	3 (6 %)	1 (2 %)
Mean	540·953 ±9·632	354·677 ±5·676	182·380 ±5·195	90·000 —	701·260 ±13·785	288·000 ±9·927	210·000
Standard Deviation ...	91·436 ±6·811	50·486 ±4·013	21·786 ±3·674	— —	138·545 ± 9·743	25·493 ±7·020	
Coefficient of Variation	16·900 ±1·270	14·230 ±1·130	11·940 ±2·020	— —	19·750 ± 1·380	8·850 ±2·430	
Range of Variation ...	435—750	225—420	120—195	—	450—975	255—315	

The most completely developed end-plate I have called *Type A*. It is nearly circular and has numerous holes varying in size (Fig. 3). In some cases the holes are less uniform with larger holes toward the centre (Fig. 4). *Type A* has a mean diameter of 541 μ with a range of 435 μ—750 μ dorsally. In the trivium *Type A* is larger, having a mean diameter of 701 μ with a range of 450 μ—975 μ. This type occurs in 48 % of the dorsal appendages and in 92 % of the ventral.

Type B (Fig. 5) has a mean diameter of 355 μ with a range of 225 μ—420 μ dorsally and therefore it is something over half the size of *Type A* in this region. In

the trivium *Type B* has a mean diameter of 288 μ with a range of 255 μ—315 μ. *Type B* occurs in 42 °/₀ of the dorsal appendages and in only 6 °/₀ of the ventral.

Type C, with the smaller holes toward the centre (Fig. 6), or with larger, irregular holes (Fig. 7), in the bivium, has a mean diameter of 182 μ with a range of 120 μ—195 μ, and in the trivium occurs but once with a diameter of 210 μ.

The most degenerate form in this species is *Type D* (Fig. 8) with a diameter of 90 μ. It only occurs once dorsally and not at all ventrally.

d. Supporting Rods.

1. *Dorsal.*

In the dorsal appendages supporting rods are present in 14 (15·9 °/₀), absent in 44 (50 °/₀) and not determinable in 30 (34·1 °/₀). Those especially characteristic of the papillae (Figs. 10, 11, 12) form a series of rib-like structures, from rods only very slightly curved and with a few spines at each end (Fig. 10) to those more bowed and spinous with the ends slightly branched (Fig. 11). Occasionally a rod is found either straight, or curved, with the ends expanded and from 1 to several holes in addition to the spines and branches. Fig. 13 presents a rare variate in the form of a rosette with a few large holes. The tentacles have supporting rods similar to the series described above for the papillae. In the tentacles the rods are confined to the branched ends and are not found in the stalks.

2. *Ventral.*

The ventral supporting rods (Figs. 20—22) are especially characteristic of the pedicels and so may be found with these appendages in the bivium. The most completely developed (Fig. 22) is a rod straight, or slightly curved, with a hole in each expanded end. Terminal prongs may grow out (Fig. 21), and then these may branch and their ends unite to form several holes at each end (Fig. 20). Connecting links (Figs. 18, 19) to the perforated plates (Fig. 17) of the body-wall can be found, lying particularly toward the base of the pedicel. So far these ventral supporting rods have not been found in their typical form in the dorsal pedicels. In some Holothurids they seem to be missing from the ventral pedicels. The curved rib-like rods of the papilla, in their typical form, are not found in the pedicel.

e. Association of Forms of Ambulacral Appendages with Types of End-plates.

In the analysis of the characters of the pedicel and the papilla it is necessary to show which characters are associated together. The following data are from the dorsal region. Of the appendages with *Type A* of end-plate 32 (78·5 °/₀) are cylindrical, none conical and 9 (21·9 °/₀), not determinable. This type may be considered as typical for the completely established pedicel. The association of *Type B* is not determinable in 21 cases (58·3 °/₀), but since the remaining 15 (41·6 °/₀) are with cylindrical appendages and none with conical, it may be

assumed that this, like *Type A*, is characteristic of the pedicel. Sometimes perhaps the presence of *Type B* may indicate that the pedicel is not fully developed.

Type C, only found in 9 °/₀ of the dorsal appendages, has a frequency of 2 (25 °/₀) in cylindrical, 2 (37·5 °/₀) in conical forms, and 3 (37·5 °/₀) not determinable. This type may be taken as an intermediate stage.

Type D occurs but once and then the form of its appendage is not determinable.

f. Association of Suckers with Types of End-plates.

Of the appendages with *Type A* end-plates 39 (95·1 °/₀) have suckers and 2 (4·9 °/₀) are not determinable and with *Type B* 32 (88·9 °/₀) have suckers, 1 (4·9 °/₀) has a rudimentary sucker, and 3 (8·3 °/₀) are not determinable. As none have them absent in these two classes and only 1 with *Type B* is rudimentary it may be assumed as the rule that *Types A* and *B* of end-plates are found in appendages having suckers.

With *Type C* the suckers are present in 2 (25 °/₀), rudimentary in 1 (12·5 °/₀), absent in 3 (37·5 °/₀) and not determinable in 2 (25 °/₀) of the appendages. The one case with *Type D* is uncertain but probably has a rudimentary sucker.

g. Association of Supporting Rods with Types of End-plates.

Of the dorsal appendages with *Type A* end-plates, supporting rods are present in 16 (39 °/₀), absent in 17 (41·5 °/₀) and not determinable in 8 (19·5 °/₀); with *Type B* they are present in 4 (11·1 °/₀), absent in 17 (47·2 °/₀) and not determinable in 15 (41·7 °/₀); with *Type C* they are present in 5 (62·5 °/₀), absent in 1 (12·5 °/₀) and not determinable in 2 (25 °/₀); and in the only one with *Type D*, the rods are present.

h. Conclusions and Definitions.

In the evolution by degeneration of the papilla from the pedicels the form has become conical with more and more pointed tip, the sucker rudimentary and finally lost, the end-plates smaller to vestigeal rosettes and supporting rods more frequent. The smaller diameter of the end-plates in the bivium, with the addition there of *Type D*, and more of *Type C*, indicates the greater progress of this evolution in the dorsal region.

The typical pedicel is cylindrical in form, with functional sucker, having end-plates of *Type A* in a large majority of the cases, the rest being of *Type B*, and dorsally with supporting rods more often absent than present.

The typical papilla is conical in form, without sucker, having end-plates of *Type D*, or *E*, and with supporting rods present.

As a connecting link between the typical pedicel and papilla is an appendage not definitely cylindrical, or conical, with suckers either present, rudimentary, or absent, having end-plates of *Type C.*

I. The Calcareous Ring.

The typical radiale of the adult (Plate V. Fig. 93), is convex anteriorly and slightly concave posteriorly. The anterior half is somewhat expanded, the sides sloping in for about one-half the length when they become straight at the junction with the inter-radialia. At the middle of the rounded anterior margin of the radiale is the notch for the radial nerve. It is 1 mm. wide, cutting into the piece for $\frac{1}{3}$ of its length and slightly increasing in breadth toward the bottom. The surface rises up from the edge of the notch to a ridge along either side. These meet a similar ridge which arises from the posterior margin. In its greatest dimensions the radiale is about 6 mm. long, 6 mm. wide, and 2 mm. thick. In the young (Fig. 97) the radiale is more delicate, more regular in outline and with the median anterior notch V-shaped and decreasing in breadth toward the bottom.

A variation (Fig. 94), not hitherto described, is often found in which there are two additional small notches cutting into the anterior margin, one toward each side. Sometimes only 1 of these notches may be found. This variate often occurs together with the normal form in the same animal.

The interradiale of the adult (Fig. 95) has a concave posterior margin and the sides run in and forwards from the lines of junction with the radialia to the anterior rounded point, thus giving the piece a somewhat triangular form. Two ridges follow the sides to unite behind the anterior end. In the young (Fig. 98) the interradiale is more delicate and the anterior sides are deeply concave, thus leaving the median portion as a bold projection.

In specimen 5 (which has only 16 tentacles) there is a fusion of the ventral and left ventral radialia and the intervening left ventral interradiale (Fig. 96). The dotted lines give the outlines of the attachment of the ventral and left ventral radial muscles.

The increase in size of the pieces of the calcareous ring, as age advances, is demonstrated by the 3 following specimens; 94, about midway in the range of the young, 42, a small adult and 56, a fairly large adult:—

Specimen		Radiale		Inter-radiale	
Number Serial	Volume c.c.	Length mm.	Width mm.	Length mm.	Width mm.
94	21	2·8	2·8	1·6	1·5
42	59	4·0	3·8	2·5	2·5
56	485	5·0	4·8	3·6	3·6

J. Polian Vesicles.

As a general rule the Polian vesicles are club-shaped and may be simple or branched (Fig. B, S, Br), coming off from the water-vascular ring as solitary vesicles, or so close together that it is difficult to determine the separate origins of some, or all, of the vesicles of a group.

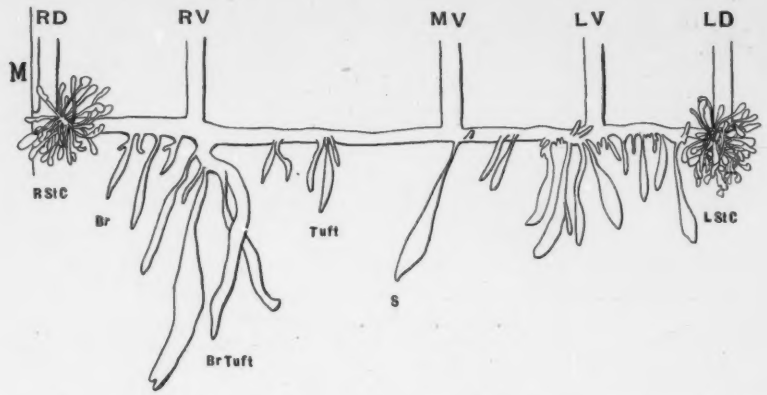


FIG. B. Water-vascular ring with Polian vesicles and stone-canals. M, Mid-dorsal mesentery. Radial canals; RD, right dorsal; RV, right ventral; MV, mid-ventral; LV, left ventral; LD, left dorsal; R St C, L St C, right and left stone-canals; S, simple, Br, Branched, Br Tuft, tuft with branched vesicles. $\times 5\frac{1}{4}$.

Such a group, when made up of simple vesicles, I have called a tuft (Fig. B, Tuft). When some, or all of the vesicles, are branched and arise either from the base of one of the vesicles of the group (Br Tuft) or directly from the water-vascular ring, it is a tuft with branched vesicles.

There are two principal groups of Polian vesicles in the region opposite the bases of the right and left ventral radial canals with small tufts and solitary vesicles in the ventral region between (Fig. B). Sometimes, as in 75 (Table II.) a Polian vesicle may have its origin near the dorsal mesentery, and again they may come off from the entire extent of the water-vascular ring. In 3 (Table I.) one Polian vesicle arises from a radial canal between the tentacle and water-vascular ring, and in 40 one large vesicle arises from the right dorsal radial canal just below the calcareous ring.

The most interesting case is specimen 17, which has a total of 92 vesicles and branches of which 32 are solitary, and of these, 3 have each 1 branch. There are 9 tufts ranging from 2—7 vesicles in a tuft. In addition there are 2 tufts with branched vesicles; the first with 2 simple vesicles and 1 with 1 branch, 1 with 3 and 1 with 4 branches.

The branching of vesicles and the formation of tufts and tufts with branched vesicles are due to the continued growth and multiplication of these organs along with the growth of the adult Holothurid, for 36 °/₀ of the adult have tufts and tufts with branched vesicles, while only 4 °/₀ of the young have tufts and none have tufts with branched vesicles. Ludwig, 1889–92, p. 113, gives *H. mexicana* and *H. africana* among the species in which several vesicles spring from a common stalk. Because of the variation in size of both vesicles and branches, in order to simplify the matter, in making Table XXII. I have grouped vesicles and branches together.

TABLE XXII.

Polian Vesicles.

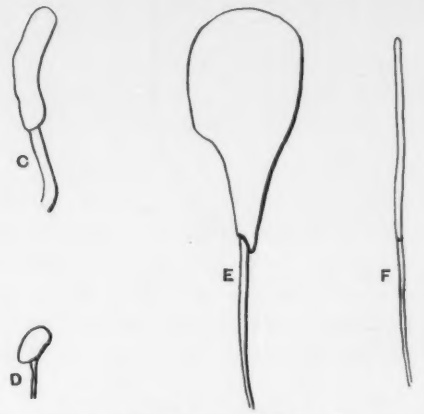
	Adult; 73 Specimens		Young; 45 Specimens	
	Number of Vesicles and Branches	Greatest Length mm.	Number of Vesicles and Branches	Greatest Length mm.
Mean	12·563 ± 1·263	25·429 ± 1·002	2·667 ± ·321	10·140 ± ·801
Standard Deviation ...	15·774 ± ·893	12·058 ± ·687	2·494 ± ·177	6·822 ± ·506
Coefficient of Variation ...	125·550 ± 7·107	47·427 ± 2·703	93·513 ± ·665	64·278 ± 4·893
Range of Variation ...	1—92	8—73	0—16	2—29

The mean number of Polian vesicles and branches is 13 with a range of 1—92, in the adult, and only 3 with a range of 0—16 in the young. Eighteen per cent. of the adult have only 1 vesicle while 74 °/₀ of the young have 1, 12 °/₀ have 2 and only 14 °/₀ have more than 2 vesicles.

The mean greatest length increased from 10 mm. with a range of 2 mm.—29 mm. in the young to 25 mm. with a range of 8 mm.—73 mm. in the adult. These facts demonstrate that, as in the formation of branches and tufts noted above, the number of vesicles and branches and their length increase with the growth of the Holothurid. Ludwig, 1889–92, p. 114, notes that most species have only 1 vesicle in the beginning, and that there are only 3 families in which these organs fail to increase in number. It is possible that most authors do not include the branches in the number of Polian vesicles given. Lampert, 1885, p. 85, notes 2 branches on the Polian vesicles. Not counting the branches, from Table I. it is found that the mean number of vesicles in the adult is 11, the four largest numbers being 40, 41, 58 and 79. Lampert, 1885, p. 85, remarks that in *H. mexicana* the Polian vesicles are very inconstant and may be conceived of as in continuous multiplication. Ludwig, 1889–92, p. 115, gives the number of Polian vesicles in *H. mexicana* as 1—13. Théel, 1886, p. 175, in describing *H. africana* says: "The Polian vesicles are numerous, up to 12 or more, of unequal size and some of them carry small branches at their base." From my series, as given above, the range of variation is greatly increased.

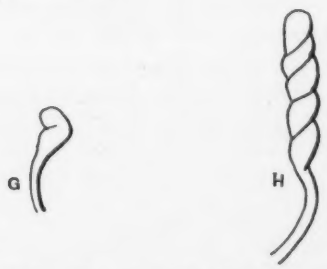
K. Stone-canals and Madreporites.

As a rule the stone-canals appear in two tufts, one slightly ventral of the base of each dorsal radius (Fig. B, R St C and L St C). In some cases from 1—7 stone-canals are separated in a line extending to 10 mm. from the dorsal mesentery.



FIGS. C—F. Stone-canals and madreporites. C, cylindrical; D, spherical; E, pear-shaped; F, profile of E. ×5¼.

In the majority of cases the madreporite is cylindrical (Fig. C), less frequently spherical (Fig. D), or pear-shaped (Fig. E). The head is compressed from side to side, presenting a narrow profile (Fig. F).



FIGS. G, H. Cylindrical madreporites. G, partly twisted; H, twisted in a spiral. ×8.

Often a cylindrical madreporite is twisted upon itself (Fig. G), or even has as many as 4 or 5 turns of a spiral (Fig. H), and frequently the stone-canals are twisted.

At times 2 madreporites are joined together. In 16, six such united pairs occur in the left tuft. In other individuals 3, 4 or 5 madreporites may be fused,

and Fig. I shows a monster composed of 6 stone-canals with the madreporites forming a common enlarged madreporic body, while the stone-canals are shortened and

Fig. I. Six stone-canals with madreporites fused. ×5½.

independent except the middle two, which have grown together. Only one stone-canal was found with 2 branches.

TABLE XXIII.

Stone Canals.

	Adult; 73 Specimens					Young; 45 Specimens				
	Number			Greatest Length mm.	Average Length mm.	Number			Greatest Length mm.	Average Length mm.
	Right	Left	Total			Right	Left	Total		
Mean	21·589	15·836	37·479	7·959	5·368	6·223	3·556	9·556	3·444	2·983
	±1·255	± ·980	±1·954	± ·327	± ·137	± ·410	± ·256	± ·605	± ·228	± ·150
Standard Deviation ...	15·903	11·894	24·748	4·140	1·734	4·076	2·543	6·021	2·266	1·488
	± ·888	± ·664	±1·381	± ·231	± ·097	± ·290	± ·180	± ·430	± ·161	± ·106
Coefficient of Variation	73·663	75·104	66·030	52·016	32·311	65·504	71·523	63·006	65·806	49·683
	±4·112	±4·192	±3·686	±1·287	±1·804	±4·657	±5·085	±4·410	±4·678	±3·532
Range of Variation ...	4—88	1—61	5—149	3—21	1·5—10·5	1—15	0—11	2—25	1—7	1·0—6·0

In the adult the mean number of right canals is 22, with a range of 4—88, and of left canals 16, with a range of 1—61. In the young the mean number of right canals is 6, with a range of 1—15 and of left canals 4, with a range of 0—11. Thus the mean number of right canals is 36 °/₀ greater than that of the left in the adult and 75 °/₀ greater in the young. This interesting asymmetry is noted for a number of species by Ludwig, 1889–92, p. 132, who gives *H. mexicana* with 8 left and 3 right canals. I find that 78 °/₀ of both the adult and young have the

greater number of canals on the right side, while only 15 °/₀ of the adult and 9 °/₀ of the young have the number greater on the left side, and 1 °/₀ of the adult and 13 °/₀ of the young have the same number on both sides. So Ludwig must have made his counts from the less frequent individuals in which the number on the left is greater.

In both adult and young the standard deviation and range of variation are greater for the right canals.

In the adult the mean total number of stone-canals is 37, with a range of 5—149, and in the young 10, with a range of 2—25, demonstrating the great increase in the number of these organs through continued budding as the Holothurid grows. Specimen 68 with the large number of 149 stone-canals is exceptional, but 37 °/₀ of the adult have more than 40 stone-canals. This should be particularly noted since Ludwig, 1889–92, p. 131, mentions *H. mexicana* as having a range of from 11—40 stone-canals. Lampert, 1885, p. 85, gives them as very numerous in two specimens of *H. mexicana*.

The mean greatest length is 8 mm. with a range of 3 mm.—21 mm. in the adult and 3 mm. with a range of 1 mm.—7 mm. in the young. To determine the average length of all the canals of an individual the mode was selected by inspection and measured. The mean average length is 5 mm. with a range of 1·5 mm.—10·5 mm. in the adult and 3 mm. with a range of 1 mm.—6 mm. in the young. Thus the number of stone-canals and their length together with their standard deviations increase with age.

L. Gonads.

The gonads are branched and form a tuft to the left side of the dorsal mesentery. The gonaduct opens dorsally just behind the circlet of tentacles. In most individuals, the sex cells mature in July and August (Edwards, 1889, p. 37).

Of the 73 adults, 35 are male, 35 female, 1 undifferentiated and 2 with gonads missing. Of the 45 young, 14 are male, 12 female, 12 undifferentiated and 7 with gonads missing.

M. Respiratory Trees.

Each of the two main stems of the respiratory tree has short branches whose median terminal twigs are intertwined with the blood-vessels of the rete mirabile.

N. The Enteric Canal.

The enteric canal is in three loops supported by a mesentery attached to the body-wall. It is large, with delicate wall and always crowded full with calcareous sand. At the posterior end is the expanded cloaca, its tough wall being attached to the body-wall by numerous small muscles.

O. Habitat.

ATLANTIC OCEAN: FLORIDA, Pourtalés, 1851; Selenka, 1867; MEXICO, Ludwig, 1874; WEST INDIES, Lampert, 1885; CUBA, *Havana*, Ludwig, 1883; Lampert, 1885; JAMAICA, Ludwig, 1883; PORTO RICO, Clark, 1901; ST THOMAS, Lampert, 1885; ST BARTHOLOMEW, GUADALOUPE, Théel, 1886; VENEZUELA, *Puerto Cabello*, Ludwig, 1883; Lampert, 1885; AZORES, Hérouard, 1902; AFRICA, CAPE OF GOOD HOPE, *Simon's Bay*, Théel, 1886.

The specimens in this paper are from BAHAMAS, ABACO, *Green Turtle Cay*; NEW PROVIDENCE, *Nassau*; FLORIDA, *Elliott's Key, Key Largo, Caesar's Creek, Indian Key, Vaca Key, Bahia Honda, between Salt Pond Key and Stock I., Key West, Tortugas*; PORTO RICO, *Boqueron Bay, Fajardo, Mayaquez, San Juan*; CUBA, *Havana*; HAITI; ST THOMAS; CARIBBEAN SEA, *Swan I., Curacoa I.*

Semper, 1868, p. 88, says that Holothurids of this species live together in great crowds upon sandy places of the coral reefs, and ordinarily are so completely covered with small sand-grains that they are noticed only by the trained eye. Gardiner, 1901–3, 1908, notes this species as one of the sand-feeders found on the sand-flats and reefs within the lagoons of the coral reefs.

III. HOLOTHURIA ATRA JÄGER.

For the characters in which *H. atra* is like *H. floridana* I will simply refer to the descriptions given above. Tables of the characters observed are given as XXIV. and XXV. on pp. 275 and 276.

A. Body.

a. FORM.

Similar to *H. floridana*.

b. SIZE.

TABLE XXVI.

1. *Length in cm.*

	Adult	Young
Number of Cases	12	8
Mean	16·367 ± 1·475	8·200 ± ·628
Standard Deviation ...	7·577 ± 1·043	2·634 ± ·424
Coefficient of Variation ...	46·295 ± 6·374	32·121 ± 5·416
Range of Variation ...	10·0—33·5	2·5—11·0

TABLE XXIV.

H. atra Jäger. Adult.

Serial Number	Length cm.	Diameter cm.	Volume cm.³	Average Thickness of Skin mm.	Sex	Polian Vesicles			Stone Canals					Tentacles	Groups of Anal Papillae	Pedicels and Papillae		Museum Number	
						Total Number	Length mm.		Number			Length mm.		Number		Distribution per sq. cm.			
							Greatest	Least	Right	Left	Total	Greatest	Average			Dorsal	Ventral	Smithsonian Institution	Harvard
150	13·6	4·1	89·78	1·5	♂♀	1	12	—	7	8	15	11	10·0	20	5	30	74	—	616
151	33·5	6·5	538·49	1·5	♂♀	19	15	1	11	10	21	8	6·0	19	*i*	8	54	—	1103
152	23·0	4·8	208·10	1·0	♂♀	35	15	2	9	9	18	6	5·5	20	*i*	16	42	—	1103
153	29·0	6·0	409·98	3·0	♂♀	36	17	1	7	10	17	16	10·0	20	4	13	41	—	1103
154	10·0	3·8	56·71	1·5	♂♀	4	22	1	4	11	15	7	6·5	20	5	11	60	—	1053
155	11·3	3·6	57·51	0·5	♂♀	5	10	2	13	11	24	6	5·5	20	*i*	10	30	6892	—
156	10·8	4·2	74·82	1·5	♂♀	56	19	12	12	7	19	9	7·5	20	5	8	21	6892	—
157	18·9	4·7	163·96	3·0	+	50	10	1	8	8	16	16	6·0	20	*i*	17	57	—	—
158	21·9	7·6	496·75	4·0	♂♀	29	42	1	10	9	19	13	11·0	19	5	8	32	6894	—
159	12·8	3·8	72·59	2·0	+	8	10	1	10	11	21	5	4·5	18	*i*	27	38	—	1055
160	12·3	3·2	49·46	1·5	+	2	9	1	27	43	70	8	5·0	18	*i*	21	36	—	640
161	11·8	5·3	130·17	1·5	+	8	16	1	25	9	34	8	5·0	21	*i*	26	48	—	640

+ undifferentiated. *i* indefinite. In 157 the Polian vesicles arise from the entire extent of the ring-canal. The volume of 160 is not quite 50 cm.³ 150—154, Hawaiian Is.; 155, Apia, Samoa; 157, Society Is.; 158, Tahiti; 159, Arabian Sea; 160, 161, Zanzibar. All but 157 and 158 were originally identified as *Holothuria floridana* Pourtalés.

TABLE XXV.

H. atra Jäger. Young.

Serial Number	Length cm.	Diameter cm.	Volume cm.³	Average Thickness of Skin mm.	Sex	Polian Vesicles			Stone Canals					Tentacles	Groups of Anal Papillae	Pedicels and Papillae		Harvard Museum Number
						Total Number	Length mm.		Number			Length mm.				Distribution per sq. cm.		
							Greatest	Least	Right	Left	Total	Greatest	Average			Dorsal	Ventral	
162	8·0	2·9	26·42	1·5	?	4	11	1	6	2	8	8	7·0	20	5	41	60	1053
163	7·8	2·8	24·02	1·5	+	4	9	1	8	5	13	4	3·5	20	*i*	22	58	?
164	10·7	2·4	24·20	1·5	+	24	17	1	5	7	12	5	5·0	20	5	30	62	1473
165	9·0	3·2	36·19	1·5	?	8	15	3	7	5	12	2	1·0	18	*i*	32	70	1473
166	6·5	2·1	11·26	1·0	+	10	15	2	1	8	9	3	2·5	18	0	39	100	1473
167	2·5	1·4	1·93	1·5	+	10	8	1	11	8	19	6	4·0	20	0	34	91	411
168	11·0	1·8	14·00	1·0	+	7	21	1	13	8	21	4	4·0	17	5	?	?	439
169	9·7	2·6	25·75	1·5	+	14	8	1	11	7	18	6	5·0	20	*i*	18	61	439

? Missing. + undifferentiated. *i* indefinite. 164 has most of the madreporites fused. 162, Hawaiian Is.; 163, Marshall Is.; 164—167, Zanzibar; 168, 169, Mozambique.

TABLE XXVII.

2. *Diameter in cm.*

	Adult	Young
Number of Cases	12	8
Mean	5·383 ± ·286	2·325 ± ·212
Standard Deviation ...	1·470 ± ·202	·600 ± ·101
Coefficient of Variation ...	27·314 ± 3·760	25·785 ± ·435
Range of Variation ...	3·2—7·6	1·4—3·2

TABLE XXVIII.

3. *Volume in cm.*^{3} $v = \frac{\pi l r^2}{2}$.

	Adult	Young
Number of Cases	12	8
Mean	170·335 ± 33·450	20·200 ± 2·495
Standard Deviation ...	171·793 ± 23·653	10·461 ± 1·764
Coefficient of Variation ...	100·856 ± 13·886	51·788 ± 8·733
Range of Variation ...	49·46—538·49	1·93—36·19

B. Colour.

The colour was determined from alcoholic specimens by the method described on p. 244 for *H. floridana.*

a. Colouration.

1. *Pedicels and Papillae.* The dorsal stalks of the adult are seal-brown in all but one individual in which they are light Prout's brown, while the ventral stalks are seal-brown except in two cases of light sepia, and one where some are drab with a ring of seal-brown. In the young both the dorsal and ventral stalks are seal-brown except in one individual where they are of the darker clove-brown. The ends of the appendages are generally coloured like the stalks, or of some lighter tint, like sepia, clay-colour, Isabella-colour, or cinnamon. Semper, 1868, p. 88, describes the ends as whitish in life.

2. *Distribution of Colour on the Body.* As graphically shown in Plate I. 160—167, the body is almost always of a uniform seal-brown. Two of the adults have blotches of light sepia on the ventral side and one has Prout's brown mid-dorsally. One of the young has a circumanal ring of dark pearl gray and another is clove-brown. Sluiter, 1895, notes a red (*steinrot*) colour in life. Pearson, 1903, speaks of some specimens when alive being quite black above but pink below. Sluiter,

1894, thinks that the variety *amboinensis* must be given up because of colour intermediates from deep black to clear yellow at the basis from which the ambulacral appendages arise.

TABLE XXIX.

C. Tentacles and Ampullae.

a. Number of Tentacles.

	Adult	Young
Number of Specimens ...	12	8
Mean	19·583 ± ·169	19·125 ± ·278
Standard Deviation ...	·868 ± ·120	1·166 ± ·196
Coefficient of Variation ...	4·430 ± ·610	6·096 ± 1·028
Range of Variation ...	18—21	17—20

The 20 tentacles normally found as the mode in *H. atra* are distributed according to the scheme of symmetry given for *H. floridana* (cf. Fig. A, Pl. V.).

Variation in the Number of Tentacles and the Relation of those Present to the Normal Symmetry.

TABLE XXX.

Variations with less than 20 *Tentacles.*

Distribution in accord with the scheme of symmetry given in Fig. A. Absence of tentacle in particular radius indicated by 0.

Age	Serial Number	Right Dorsal				Left Dorsal				Right Ventral				Left Ventral				Mid-Ventral				Total Number
		d1	*d2*	*v2*	*v1*	*d1*	*d2*	*v2*	*v1*	*d1*	*d2*	*v2*	*v1*	*d1*	*d2*	*v2*	*v1*	*l1*	*l2*	*r2*	*r1*	
Adult	*151*	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19
	158	—	—	—	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19
	159	—	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	—	—	18
	160	—	—	—	—	—	—	0	—	—	—	0	—	—	—	—	—	—	—	—	—	18
Young	*165*	—	0	—	—	—	—	—	—	—	—	—	—	—	0	—	—	—	—	—	—	18
	166	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	—	18
	168	—	0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	—	17

Among the 8 variates there is the same decided tendency to reduction in the number of tentacles as shown in *H. floridana*, since 7 (87·5 %) have less than the normal number of 20. Only 1, an adult, 161, with 21 tentacles has more than the norm. The extra tentacle is *d*3, left dorsal radius, and all 5 tentacles of the dorsal inter-radius are in asymmetry, to the left of the mesentery. In 151, 158 and 160 the mesentery is attached at the junction of the dorsal inter-radiale with the right dorsal radiale; in 161, far over on the right dorsal radiale.

b. Branches on Tentacular Ampullae and Variation in their Number.

Only 1 Holothurid, 151, varies from the norm in having branches to the ampullae. There are in all 25 branches distributed as follows: right dorsal radius $d2(1)$, $v2(1)$, mid-ventral radius $rl(1)$, $r2(2)$, $l2(1)$, $l1(5)$, left ventral radius $v1(1)$, $v2(1)$, $d2(1)$, left dorsal radius $v1(2)$, $v2(1)$, $d1(8)$. This case is even more remarkable than 7 of *H. floridana* (p. 252), and since with a volume of 538 cm.³ it is the largest individual in the series it shows that the branching of the ampullae, when it appears, is associated with the more advanced age. One specimen, 155, has 1 of its tentacles of small size.

D. Pedicels and Papillae.

a. Distribution per sq. cm.

(Counted as in *H. floridana*, p. 253.)

TABLE XXXI.

	Dorsal		Ventral	
	Adult	Young	Adult	Young
Number of Specimens ...	12	8	12	8
Mean	16·584 ± 1·612	30·572 ± 2·011	44·500 ± 2·651	72·714 ± 4·114
Standard Deviation ...	8·281 ± 1·140	7·889 ± 1·422	13·617 ± 1·875	16·138 ± 2·909
Coefficient of Variation ...	49·935 ± 6·875	25·807 ± 4·652	30·599 ± 4·213	22·194 ± 4·001
Range of Variation ...	8—30	18—41	21—74	58—100

Table XXXI. demonstrates that in the adult there are 2·6 as many appendages in the ventral region as in the dorsal, and in the young 2·4 as many. In both the adult and young the standard deviation is much greater in the ventral region*. Compared with *H. floridana*, the appendages are more numerous and crowded, especially in the trivium. Selenka, 1867, p. 326, notes that the ventral pedicels are more numerous in the older examples. Östergren, 1907, p. 195, notes the presence among the larger pedicels of numerous very small pedicels which hold fast the protective covering of weeds and other foreign bodies.

[* In this as in several other cases cited by the author, the statement as to variability depends upon using the standard-deviation and not the coefficient of variation as the measure of variability.—Ed.]

TABLE XXXII.

b. Distribution of Papillae around the Anus.

Age	In Groups						Indefinite	Total
	Number of Groups							
	0	*1*	*2*	*3*	*4*	*5*		
Adult ...	0	0	0	0	1	4	7	12
Young ...	2	0	0	0	0	3	3	8

Table XXXII. shows that all of the adults have anal papillae. In 42 °/₀ the papillae are in groups, and in 58 °/₀ they are indefinitely distributed. Of the 8 young, two have no anal papillae, three have 5 groups and three have the papillae indefinitely distributed.

E. The Body-wall.

a. Thickness in mm.

(Determined as in *H. floridana*, p. 256.)

TABLE XXXIII.

	Adult	Young
Number of Specimens ...	12	8
Mean	1·717 ± ·173	1·575 ± ·052
Standard Deviation ...	·886 ± ·122	·217 ± ·037
Coefficient of Variation ...	51·599 ± 7·104	13·746 ± 2·318
Range of Variation ...	·6—4·0	1·0—1·5

The mean thickness of the body-wall is only ·14 mm. greater in the adult than in the young. The range in the adult shows one 4 mm. thick, but in most cases it cannot be said to grow much thicker with age, in which it differs decidedly from *H. floridana* (cf. p. 256). In *H. floridana* the mean thickness of body-wall is 2·4 greater than in *H. atra*. Thus the body-wall in *H. atra* is comparatively thin, soft and flaccid while in *H. floridana* it is nearly always much thicker, and even when not thicker, it is usually hard and firm, especially in the adult. Lindmann, 1899, claims that in the changes of consistency in the body-wall from hard to soft the albuminous element of the slime-secretion plays the most important part. While this may be true of the physiology of these tissues, yet I should account for the specific difference above noted in the greater thickness and the much larger number of spicules found in the body-wall of *H. floridana* (cf. p. 256). The standard deviation, especially in the young of *H. atra*, is very small.

b. PITS.

Over most of the surface of the body and the ambulacral appendages are found shallow, crater-like depressions which may be called pits (Fig. J).

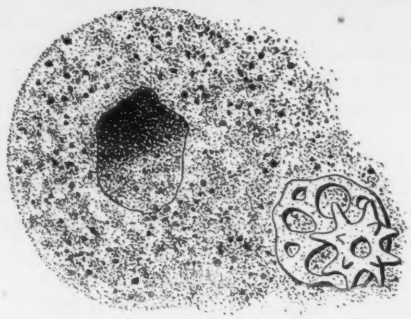


FIG. J. Pit with thick, pigmented wall. A table lies just beyond the outer edge of the pit. ×320.

The mean dimensions are about ·15 mm. × ·1 mm. and their centres, in general, average about ·3 mm. apart. Each has a thickened pigmented wall (Fig. K) in which epidermal cells are crowded and which is more or less clearly separated from the surrounding tissue by crescentic clefts (*x*).

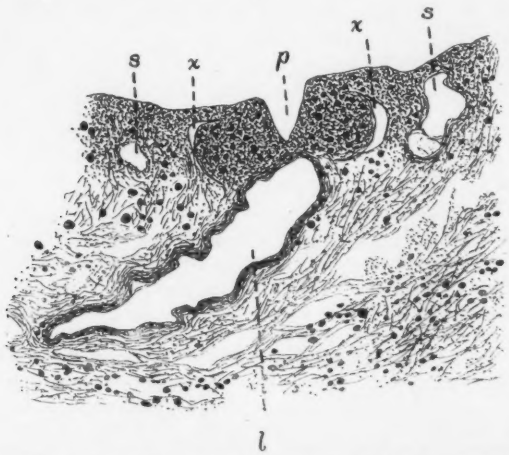


FIG. K. Section of pit; *p*, pit; *x*, *x*, clefts separating wall from surrounding tissues; *l*, lacuna; *s*, *s*, spaces from which tables have been dissolved. ×400.

The opening of the pit is either approximately circular (Fig. J) or else slightly elongated and about ·057 mm. × ·03 mm. At times when the lip of the pit is

nearly closed the opening is a narrow slit. In sections it is seen that beneath the blind bottom of the funnel-shaped pit (Fig. K) there is a closed lacunar space, sometimes spherical, but more frequently drawn out into an elongated canal-like space (*l*). The sections show the characteristic loosely woven connective tissue fibres and the spaces (*s*) from which spicules like the tables in (Fig. J) have been dissolved. Fisher (1907) seems not to have noticed my preliminary paper (1905) in which these pits were first mentioned, and hence has failed to include in his description these and some of the other characters by means of which I have clearly differentiated *H. atra* from *H. floridana.*

F. Calcareous Spicules of the Body-wall.

The spicules are not so numerous as in *H. floridana* and the warts found in that species do not occur.

a. Tables.

For the general description of the development, structure and variation of the tables there is no distinction to be made from *H. floridana* (cf. p. 256 *et seq.*).

b. Tables of Bivium and Trivium in H. atra.

For this study data were taken from 16 specimens collected all the way from the Hawaiian Islands to Mozambique. Ordinarily 10 tables were taken from each

TABLE XXXIV.

Tables of Bivium and Trivium.

		Disc				Crown			
		Number of Peripheral Holes	Number of Spines	Diameter μ	Height μ	Number of Teeth	Diameter of Hole μ	Diameter not including Teeth μ	Diameter including Teeth μ
Dorsal	Mean	3·740 ± ·069	·713 ± ·097	47·927 ± ·251	65·870 ± ·590	11·960 ± ·055	9·225 ± ·148	19·710 ± ·156	44·030 ± ·300
	Standard Deviation	1·257 ± ·049	1·753 ± ·683	4·558 ± ·178	9·780 ± ·416	·999 ± ·039	2·637 ± ·105	2·779 ± 1·101	5·439 ± ·212
	Coefficient of Variation	31·008 ± 1·208	245·65 ± ·957	9·511 ± 3·704	14·840 ± ·624	8·355 ± ·325	28·580 ± 1·136	14·100 ± ·569	12·350 ± ·500
	Range of Variation	0—9	0—10	35·2—60·8	41·92—92·22	8—15	3·2—19·2	12·8—25·6	32·0—57·6
Ventral	Mean	3·578 ± ·094	·669 ± ·094	44·603 ± ·326	47·629 ± ·449	12·162 ± ·063	9·190 ± ·155	18·780 ± ·150	38·756 ± ·337
	Standard Deviation	1·652 ± ·066	1·667 ± ·068	5·763 ± ·231	7·355 ± ·318	1·117 ± ·045	2·709 ± ·110	2·626 ± ·106	5·953 ± ·238
	Coefficient of Variation	46·100 ± 1·845	249·07 ± ·997	12·920 ± 5·199	15·432 ± ·068	9·187 ± ·367	29·476 ± 1·192	14·000 ± ·577	15·350 ± ·623
	Range of Variation	0—9	0—9	28·8—60·8	31·1—70·0	8—15	3·2—16·0	12·8—28·8	25·6—57·6

of the dorsal and ventral regions. The determinations for the species, recorded in Table XXXIV. were made from a total of 150 dorsal and 142 ventral tables.

1. *Disc.*

In the form of the disc, *dorsally* there are 119 (79·3 °/₀) square, 13 (8·7 °/₀) irregularly square, 13 (8·7 °/₀) round, 2 (1·3 °/₀) irregularly round, and 3 (2 °/₀) irregular; *ventrally*, 92 (64·8 °/₀) square, 16 (11·3 °/₀) irregularly square, 18 (12·7 °/₀) round, 7 (4·9 °/₀) irregularly round, 9 (6·3 °/₀) irregular. In general, square may be taken as the prevailing form.

The mean number of peripheral holes is 4, which is from 1 to 2 less than in *H. floridana*. Pearson, 1903, p. 202, notes that "the discs of the tables are smooth and have no peripheral perforations." The study of my series shows that Pearson's description cannot be held as typical for the species.

The mean number of spines is ·7 while 82 °/₀ of the tables have discs without spines. In all of the characters of the disc this species agrees closely with *H. floridana* (cf. p. 258).

2. *Height.*

The dorsal tables are 66 μ high, 38 °/₀ higher than the ventral, and altogether they are higher in *H. atra* than in *H. floridana*.

3. *Crown.*

The mean diameter, both including and not including teeth, the length of the teeth and the mean diameter of the hole, are slightly greater in this species than in *H. floridana*.

The mode for the number of teeth is 12; the mean being slightly less dorsally and slightly more ventrally.

As in the case of *H. floridana*, the dorsal tables have more peripheral holes, more spines, broader crown, larger crown-hole and longer teeth than the ventral tables, albeit in some characters the differences are so small as scarcely deserving of notice, while the number of teeth is slightly greater ventrally.

c. Rosettes and Rosettes with Holes.

In its simple condition the rosette has a somewhat elongated central bar with forked ends (Pl. IV. Fig. 23). The ends fork (Fig. 24), and the branches thus formed grow toward one another. Later additional branches may appear at the middle of the central bar (Fig. 25). A large majority of the rosettes remain open as in Figs. 24 and 25, although the curved ends of contiguous branches are often in apposition. On some of the rosettes are little knobs, while others present slight irregularities of the surface which might be taken for knobs.

When the distal portions of any two of these branches fuse, a hole is formed (Fig. 26) and such a spicule is placed in the class of rosettes with holes (Figs. 26—27 f). In the bivium there are 145 (96·7 °/₀) rosettes and 5 (3·3 °/₀) rosettes

with holes, and in the trivium 130 (86·7 °/₀) rosettes and 20 (13·3 °/₀) rosettes with holes.

TABLE XXXV.

Rosettes and Rosettes with Holes.

		Rosettes		Rosettes with Holes		
		Greater Diameter μ	Smaller Diameter μ	Number of Holes	Greater Diameter μ	Smaller Diameter μ
Dorsal	Mean	24·662	17·148	1·400	24·000	19·200
		± ·220	± ·157	± ·121	± 2·569	± 1·289
	Standard Deviation ...	3·931	2·803	·400	8·518	4·293
		± ·156	± ·111	± ·085	± 1·817	± ·916
	Coefficient of Variation	15·941	16·348	28·571	35·492	22·351
		± ·631	± ·698	± 6·094	± 7·570	± 4·767
	Range of Variation ...	9·6—33·6	9·6—24·0	1—2	19·2—33·6	14·4—24·0
Ventral	Mean	24·886	17·022	1·350	26·400	18·240
		± ·279	± ·154	± ·099	± ·886	± ·369
	Standard Deviation ...	4·717	2·597	·654	5·873	2·448
		± ·197	± ·109	± ·070	± ·626	± ·261
	Coefficient of Variation	18·954	15·259	48·430	22·247	13·418
		± ·793	± ·638	± 5·165	± 2·373	± 1·431
	Range of Variation ...	14·4—43·2	9·6—24·0	1—3	19·2—38·4	14·4—24·0

In their general dimensions and the increased size of the rosettes with holes these spicules in *H. atra* agree with those of *H. floridana*. Only 3 °/₀ in the dorsal region are rosettes with holes and 13 °/₀ in the ventral region. Of the 25 rosettes with holes found among the 300 rosettes and rosettes with holes of my statistical series, only two have 3 holes, four have 2 holes and 19 have 1 hole.

The rosette with holes (perforated plate) of *H. atra* is often more or less similar to the developmental stages of the perforated plate in *H. floridana*. The rosettes nearly always show some of the arching of the branches of the bar (Figs. 24, 25), preliminary to the formation of the two central and the one or more distal holes of developmental *Types a* (Fig. 37) and *b* (Fig. 38) of *H. floridana*. Thus Fig. 27 a resembles *Type a*. *Type b* with the 4 additional distal holes, 2 at each end, is often clearly indicated, albeit rarely, if ever, having all the distal holes completed (Fig. 27 b). (Cf. Selenka, 1867, Pl. VII. Fig. 4.)

Occasional somewhat elongated "buttons" occur with two pairs of larger central holes and one distal hole at each end (27 c). In one case there is an incomplete button of this type but with three pairs of central holes (Fig. 27 d). This button is formed from *Type a* by the growth of a bar through each central hole. Fig. 27 a shows such a bar projecting into the right central hole. If in a

rosette like Fig. 25 with median lateral bars the apposed terminal processes fused, a button like the above would result. In 156, from Samoa, there is a marked tendency toward the formation of these patterns.

But even when holes are present the ends of the rosette branches curl out and project freely, only very rarely forming the smooth contour often found in *Types a* and *b* of *H. floridana*. In my statistical series 6 °/₀ have one hole (Fig. 26); 1 °/₀ two holes and *only a fraction of* 1 °/₀ *more than two holes* (Fig. 27). By special searching outside of the statistical series rosettes were found with as many as six holes completely formed (Figs. 27 b—d). EVEN THEN THE FULLY DEVELOPED PERFORATED PLATES OF H. FLORIDANA (Figs. 39—41), WITH A MEAN NUMBER OF 13—15 HOLES, ARE DISTINCTLY DIFFERENT FROM ANY FOUND IN H. ATRA. So also the rosettes differ in the two species. In *H. atra* they are more elongated, the parts more nearly at right angles to one another and the whole more delicate, while in *H. floridana* they are stellate, appear heavier, often thicker at the centre and the branches have swollen ends (cf. Figs. 23—27 d with 28—33). Sometimes rosettes like those of *H. atra* are found in *H. floridana*, as well as stages intermediate to the stellate form typical of the latter species. The possession of peculiar perforated plates and in almost all cases the different kind of rosettes, are among the chief characters which have led me to separate and re-establish *H. floridana* as a distinct species.

Number per sq. cm.

One hundred of these spicules were counted in the field (·2 sq. mm.) of a 1 in. ocular and a ¼ in. objective, and thus to each sq. cm. of surface there could be 50,000 spicules. The possible error in this calculation may be placed at 50 °/₀. As a general rule these spicules are much more crowded in *H. floridana* (cf. p. 263) but there are exceptions like 30 of that species, which has scarcely more spicules than the least number in *H. atra*.

G. Calcareous Spicules of the Ambulacral Appendages and the Differentiation of Pedicels and Papillae.

From 13 Holothurids, 204 dorsal ambulacral appendages were taken, and from 3 specimens, 53 ventral appendages. Certain characters were not determinable, or absent, in some cases.

a. FORM.

In form 18 (8·8 °/₀) are cylindrical, 26 (12·8 °/₀) conical, but chiefly because of much contraction, 160 (78·4 °/₀) of the dorsal ambulacral appendages were not determinable. From those determined it may be assumed that a considerable majority in the bivium are conical in *H. atra*, instead of cylindrical as in *H. floridana*.

b. SUCKERS.

Suckers are present in 31 (15·2 °/₀), rudimentary in 1 (·5 °/₀), absent in 121 (59·3 °/₀) and not determinable in 57 (25 °/₀).

The absence of a sucker is characteristic of the papilla, and since 59 °/₀ of the dorsal appendages lack this organ they may be considered as papillae.

c. End-plates.

In 12 (5·9 °/₀) of the dorsal appendages there is no trace of an end-plate, a condition which only occurs in 1 °/₀ of the dorsal appendages of *H. floridana*. In 2 (1 °/₀) the end-plate was not determinable.

TABLE XXXVI.

Diameter of End-plates in μ.

	Dorsal					Ventral				
	A	*B*	*C*	*D*	*E*	*A*	*B*	*C*	*D*	*E*
Frequency	1 (·5 °/₀)	89 (46·8 °/₀)	70 (36·8 °/₀)	22 (11·6 °/₀)	8 (4·3 °/₀)	38 (71·7 °/₀)	10 (18·9 °/₀)	3 (5·7 °/₀)	1 (1·9 °/₀)	1 (1·9 °/₀)
Mean	450·00	283·652	169·349	107·727	78·750	669·473	339·000	175·001	105·000	60·000
		±3·778	±2·262	±3·367	±4·979	±10·687	±11·720	±7·286		
Standard Deviation	—	52·812	27·858	23·412	20·879	97·671	54·950	18·710		
		±2·670	±1·600	±2·381	±3·521	± 7·557	± 8·288	±5·152	—	—
Coefficient of Variation	—	18·619	16·450	21·733	26·512	14·589	16·209	10·691		
		± ·941	± ·945	±2·210	±4·471	± 1·129	± 2·445	±2·944	—	—
Range of Variation	—	225—420	105—210	60—135	60—120	465—825	240—405	150—195	—	—

In the bivium there is only one end-plate of *Type A*, with a diameter less than that of the smallest variate of this type in the trivium. *Types A*, *B* and *C* are larger and more variable in the trivium, and each of the vestigeal rosette-like end-plates, *D* and *E*, is found but once, while dorsally *D* occurs in 12 °/₀ and *E* in 4 °/₀ of the cases.

Comparing Table XXXVI. with Table XXI. it is seen that in *H. floridana* the mean diameters of all the types are larger, while in *H. atra* only one dorsal end-plate is large enough to be placed in *Type A*. So, from a consideration of the end-plates, it is obvious that the evolution by degeneration of the papilla from the primitive pedicel is much more marked dorsally in both species, and that all over the body it has proceeded decidedly farther in *H. atra* than in *H. floridana*. Selenka, 1867, p. 326, notes that specimens from the South Sea have the end-discs ¼ smaller than those from Florida.

d. Supporting Rods.

Dorsal.

In the bivium supporting rods are absent in 146 (71·6 °/₀) of the appendages, present in 32 (15·7 °/₀) and not determinable in 26 (12·7 °/₀). The description given on p. 266 covers the dorsal supporting rods of this species.

e. SUPPORTING ROSETTES AND SUPPORTING PLATES.

Ventral.

The supporting rosettes are found in the wall of the sucker near the end-plate. The terminations of the central bar are broadly branched nearly at right angles to the bar and the spreading branches are often fused to form holes (Figs. 15, 16). In some cases terminal twigs from the opposite ends grow together, thus forming perforated plates with two especially large central holes (Fig. 14). These are the fenestrated, often symmetrically bilateral plates described by Théel, 1886, p. 181.

f. ASSOCIATION OF FORM OF AMBULACRAL APPENDAGES WITH TYPES OF END-PLATES IN THE BIVIUM.

Type A only occurs once and in a cylindrical appendage. *Type B* was not determinable in 61 (67·8 °/₀) cases but in the 29 (32·2 °/₀) determinable is in cylindrical appendages. *Type C* is in cylindrical appendages in 3 (4·3 °/₀), in conical 6 (8·7 °/₀) and was not determinable in 60 (87 °/₀). *Type D* was not determinable in 17 (77·3 °/₀) but in the 5 (22·7 °/₀) determinable is in conical appendages. *Type E* was not determinable in 4 (50 °/₀) but like *Type D* when determinable, 4 cases (50 °/₀), is in conical appendages.

g. ASSOCIATION OF SUCKERS WITH TYPES OF END-PLATES.

The one appendage with *Type A* end-plate has a sucker. With *Type B* suckers are present in 25 (27·8 °/₀), rudimentary in 1 (1·1 °/₀), absent in 33 (36·7 °/₀) and not determinable in 31 (34·4 °/₀). With *Type C* suckers are present in 4 (5·8 °/₀), absent in 51 (73·9 °/₀), and not determinable in 14 (20·3 °/₀). With *Type D* suckers are absent in 20 (90·9 °/₀) and not determinable in 2 (9·1 °/₀), and with *Type E* present in 1 (12·5 °/₀), absent in 6 (75 °/₀), and not determinable in 1 (12·5 °/₀). In two appendages without end-plates one has a sucker and one has not.

When compared with *H. floridana* the absence of suckers with *Type B* is especially noticeable, showing, perhaps, that the sucker is lost first and then follows the degeneration of the end-plate.

h. ASSOCIATION OF SUPPORTING RODS WITH TYPES OF END-PLATES.

In the one appendage having *Type A*, supporting rods are absent. With *Type B* they are absent in 64 (71·1 °/₀) and not determinable in 26 (28·9 °/₀). With *Type C* supporting rods are present in 6 (8·7 °/₀), absent in 58 (84·1 °/₀) and not determinable in 5 (7·2 °/₀). With *Type D* they are present in 40 (40·9 °/₀), absent in 54 (54·5 °/₀) and not determinable in 4 (4·5 °/₀), and with *Type E*, present in 4 (50 °/₀) and absent in 4 (50 °/₀).

In the cases determinable supporting rods are absent in appendages having end-plates of *Types A* and *B* and in the large majority of those having *Type C*, while they are about as often absent as present in those having *Types D* and *E*. In the two appendages without end-plates supporting rods are present.

i. Conclusions and Definitions.

While agreeing in general with the conclusions and definitions for *H. floridana* (p. 267), *H. atra* has part of the appendages with *Type B* end-plates, without suckers, and represents a more specialized stage in evolution, with the addition of *Types D* and *E* of end-plates in the trivium and *Type E* in the bivium.

H. The Calcareous Ring.

The calcareous ring, including the variation of the radialia with notches, is similar in form to that of *H. floridana* but about twice as large.

The growth in the pieces of the calcareous ring is shown in the two following specimens, *155*, a small adult, and *158*, a large adult:—

Specimen		Radiale		Inter-radiale	
Serial Number	Volume cm.³	Length mm.	Width mm.	Length mm.	Width mm.
155	58	5·0	5·5	4·0	2·5
158	497	7·5	6·7	5·8	6·0

Selenka, 1867, p. 326, notes that specimens from the Sandwich Islands have ⅓ larger calcareous ring. Comparing the area of the radiale, 28 sq. mm. in the young adult, *155*, with that of a specimen of *H. floridana* of nearly equal volume, 15 sq. mm. in *42* (cf. p. 268), it is seen that the radiale is 87 °/₀ larger in *H. atra*. In the same way the inter-radiale is shown to be 67 °/₀ larger. Comparing older adults *158* and *56* the volume of the former being 12 c.c. greater (cf. p. 268), the radiale is found to be 108 °/₀ and the inter-radiale 169 °/₀ larger in *H. atra*.

I. Polian Vesicles.

The Polian Vesicles are club-shaped and in general arise from the water-vascular ring in two principal groups opposite the bases of the right and left ventral radial canals. In one case, *157*, the vesicles arise from the entire extent of the ring-canal.

TABLE XXXVII.

Polian Vesicles.

	Adult; 12 Specimens		Young; 8 Specimens	
	Number of Vesicles	Greatest Length mm.	Number of Vesicles	Greatest Length mm.
Mean	20·750±3·835	17·000±1·639	9·500± 1·460	13·250±1·299
Standard Deviation ...	19·698±2·712	8·416±1·159	6·124± 1·033	5·449± ·949
Coefficient of Variation ...	94·930±6·325	49·505±6·816	64·458±10·869	41·121±6·934
Range of Variation ...	1—56	9—42	4—24	8—21

Pearson, 1903, p. 203, notes 3 specimens, each with one Polian vesicle.

The mean number of Polian vesicles is 21, with a range of 1—56, in the adult and 10, with a range of 4—24, in the young. Ludwig, 1889–92, p. 115, gives the range as 1—10. The smallest Holothurid, *167*, has 10 Polian vesicles, and the smallest number any specimen has is 4. Thus *H. atra* shows a considerable difference from *H. floridana*, in which 74 % of the young have only one Polian vesicle. The mean greatest length increased from 13 mm. with a range of 8 mm. —21 mm. in the young, to 17 mm. with a range of 9 mm.—42 mm. in the adult.

J. Stone-canals and Madreporites.

The stone-canals and madreporites agree in location and form with *H. floridana* (p. 271). In *164* most of the madreporites are fused.

TABLE XXXVIII.

Stone-canals.

	Adult; 12 Specimens					Young; 8 Specimens				
	Number			Greatest Length mm.	Average Length mm.	Number			Greatest Length mm.	Average Length mm.
	Right	Left	Total			Right	Left	Total		
Mean	11·000	12·000	24·084	9·500	7·117	8·250	6·375	13·250	4·750	4·325
	±1·433	± 1·769	±2·933	± ·744	± ·428	± ·789	± ·394	±1·155	± ·426	± ·623
Standard Deviation ...	7·360	9·083	15·064	3·819	2·248	3·307	1·654	4·842	1·788	1·763
	±1·013	± 1·251	±2·074	± ·526	± ·310	± ·558	± ·279	± ·816	± ·302	± ·297
Coefficient of Variation	66·906	75·692	62·547	40·195	31·594	40·085	25·937	36·540	37·644	40·700
	±9·212	±10·421	±8·612	±5·534	±4·350	±6·759	±4·374	±6·162	±6·348	±6·875
Range of Variation ...	4—27	7—43	15—70	5—16	4·5—11	1—13	2—8	8—21	2—8	1—7

In the adult the mean number of right canals is 11, with a range of 4—27 and of left canals, 12, with a range of 7—43. In the young the mean number of right canals is 8, with a range of 1—13 and of left canals 6, with a range of 2—8. With the mean number of right and left canals about the same in the adult, the left being slightly larger, what asymmetry is present is the opposite to that in *H. floridana*. In the young the asymmetry agrees with that of *H. floridana* but is less extensive. In the adult the mean total number of stone-canals is 24, with a range of 15—70, and in the young, 13, with a range of 8—21, not so great an age difference as shown in *H. floridana*. The mean total number in the adult is 54 % greater in *H. floridana*. Ludwig, 1889–92, p. 131, gives the range as 10—70 in *H. atra*.

The mean greatest length is 10 mm. with a range of 5 mm.—16 mm. in the adult, and 5 mm. with a range of 2 mm.—8 mm. in the young.

Thus the number of stone-canals and their length increase with age. The mean average length in the adult is 40 % greater than in *H. floridana*. Selenka, 1867, p. 326, observes that the stone-canals in specimens from the South Sea are about ½ longer, but not so many as in Florida specimens.

K. Gonads.

The gonads and gonaduct agree with those of *H. floridana*. Of the 12 adults 7 are male, 2 female, and 3 undifferentiated. Of the 8 young, 6 are undifferentiated and 2 have the gonads missing. This undifferentiated state is in harmony with the conclusion of Mitsukuri, 1902, p. 18, for *Stichopus japonicus*, that the first-year young and many of the second-year young have the gonads in an undeveloped condition.

L. Respiratory Trees.

Similar to *H. floridana*.

M. The Enteric Canal.

Gardiner, 1901–3, pp. 338—40, has studied the important function of *H. atra* and other forms, in reducing coral fragments to sand. The coarser fragments are retained in the gut, somewhat reduced in size, while the finer particles are swept along the gut, "presumably along its ciliated fold or groove."

N. Habitat.

INDIAN OCEAN, Lampert, 1885; MOZAMBIQUE, Bell, 1884; MADAGASCAR, *Nossibe*, Ludwig, 1883; ALDABRA IS., Voeltzkow, 1902; ZANZIBAR, Selenka, 1867; Ludwig, 1877, 1887, 1899; Lampert, 1885, 1896; *Tumbat I., Baui*, Lampert, 1896; AMIRANTE IS., Bell, 1884; *Darros I.*, Lampert, 1885, Bell; *Querimba* (*S.E. Coast, Africa*), Lampert, 1885; RED SEA, Semper, 1869; Ludwig, 1887 a; *Kossmann*, Lampert, 1885; *Djedda*, Lampert, 1885; Ludwig; LACCADIVE

AND MALDIVE IS., Gardiner, 1901–3; CEYLON, Bell, 1887; Ludwig, 1887; Thurston, 1890; *Gulf of Manaar, Trincomalee, Galle*, Pearson, 1903; BAY OF BENGAL, Bell, 1888; MERGUI ARCHIPELAGO, *Elphinstone I.*, Bell, 1886; NICOBAR IS., Semper, 1868; Lampert, 1885; EAST INDIA IS., Koehler, 1895; Koningsberger, 1904; SUMATRA, *Padang*, Ludwig; Lampert, 1885; JAVA, Selenka, 1867; Lampert, 1885; *Batavia*, Sluiter, 1887; *Sunda*, Lampert, 1885; *Saleh-Bai, Sebangkatan, Lombok, Lumu-Lumu, Seba* (*Savu*), *Kabala dua, Lucipara I., Haingsisi, Roma, Kangeang, Timor, Jedan*, Sluiter, 1901; *Timor I.*, Ludwig; Lampert, 1885; *Ambon*, Sluiter, 1894, 1895; CELEBES, Jäger, 1833; *Macassar*, Lampert, 1885; MOLUCCA OR SPICE IS., Semper, 1868; *Amboina*, Selenka, 1867; Semper, 1868; Lampert, 1885; Théel, 1886; *Batjan*, Semper, 1868; Lampert, 1885; *Ternate*, Marenzeller, 1900; *Pulo Tikul*, Lampert, 1885; *Pulu Tibul*, Ludwig; PHILIPPINE IS., Semper, 1868; *Cebu*, Lampert, 1885; *Mermaidstreet, Lucepara I.*, Lampert, 1889; AUSTRALIA, *Adelaide*, Lampert, 1885; *Great Barrier Reef*, Kent, 1893; PACIFIC OCEAN, CAROLINE IS., *Ualan I.*, Brandt, 1835 (Ludwig, 1881); RADACK CHAIN, Chamisso and Eysenhardt, 1821; GILBERT IS., *Paanopa* (*Ocean I.*), *Nauru* (*Pleasant I.*), Whitelegge, 1903; ELLICE IS., *Funafuti*, Whitelegge, 1897; Hedley, 1899; Bedford, 1899 a; *Rotuma*, Bedford, 1899 a; FIJI IS., Théel, 1886; LOYALTY IS., Bedford, 1899; SAMOAN IS. (NAVIGATOR IS.), Semper, 1868; *Viti*, Graeffe; TONGA IS., *Penope*, Théel, 1886; SOCIETY IS., Selenka, 1867; Lampert, 1885; *Tahiti*, Ludwig, 1883; HAWAIIAN IS., Selenka, 1867; Lampert, 1885; Fisher, 1907; CLIPPERTON I., Clark, 1902.

The specimens in this paper are from MOZAMBIQUE; ZANZIBAR; ARABIAN SEA; MARSHALL IS.; SAMOA, *Apia*; SOCIETY IS., *Tahiti*; HAWAIIAN IS., and GALAPAGOS IS. (the last in the collection of Dr H. L. Clark).

IV. SUMMARY.

A. Characters separating H. floridana Pourtalés (= H. mexicana Ludwig, H. africana Théel) from H. atra Jäger.

<table>
<tr><th></th><th colspan="4">*H. floridana* Pourtalés</th><th colspan="4">*H. atra* Jäger</th></tr>
<tr><td>Colouration</td><td colspan="4">The lighter tints of the browns prevail as the ground-colour. The markings are dots, spots, blotches, streaks or rings of the browns, creams, grays and whites.
Only 12°/₀ of the adult and 40°/₀ of the young have the entire body uniformly coloured. In all such cases the dark browns, usually seal and clove, are found. 60°/₀ of the adult and 13°/₀ of the young have the mid-dorsal region uniform in the browns. When the colours of this region are mixed the dark browns (seal, clove, Vandyke) predominate with some intermixture of creams and grays.
The lateral-dorsal regions are not half so uniform as the mid-dorsal and with a tendency to the lighter browns and creams.
The ventral region shows almost as much uniformity as the mid-dorsal in the adult, and almost three times as much in the young. The lighter browns and creams prevail in the adult and these colours together with the grays in the young.
In the adult the percentage of creams is doubled from mid- to lateral-dorsal and again from lateral-dorsal to ventral, thus gradually changing the colour from the dark brown back to the lighter belly.
Over the entire body the ends of the ambulacral appendages often arise from dark brown, or black, spots.
The young are more variegated but altogether these partly-coloured holothurians show much variation in the often fantastic combinations of the 25 tints of the browns, the 4 tints of the creams, the 9 tints of the grays, black and white.</td><td colspan="4">Mostly uniform seal-brown in both the adult and young. The ends of the appendages may be of a lighter tint like sepia.</td></tr>
<tr><td rowspan="2">Distribution of pedicels and papillae per sq. cm.</td><td colspan="2">Bivium</td><td colspan="2">Trivium</td><td colspan="2">Bivium</td><td colspan="2">Trivium</td></tr>
<tr><td>Adult 13</td><td>Young 21</td><td>Adult 25</td><td>Young 35</td><td>Adult 17</td><td>Young 31</td><td>Adult 45</td><td>Young 73</td></tr>
<tr><td>Number per sq. cm.</td><td colspan="4">1·6 as many in trivium as in bivium in adult and 1·4 in young.</td><td colspan="4">2·6 as many in trivium as in bivium in adult and 2·4 in young. 65°/₀ more appendages in *H. atra* than in *H. floridana*.</td></tr>
<tr><td>Skin</td><td colspan="4">*Warts*, each a heap of rosettes and perforated plates usually surmounted by a papilla. Found in 63°/₀ of adult, 98°/₀ of young, and in all larvae. In remaining 37°/₀ of adult and 2°/₀ of young warts probably present but not conspicuous and hence not seriated as such. In young warts most often in prominent right and left lateral rows.</td><td colspan="4">*Pits*, shallow, crater-like depressions (·15 mm. × ·1 mm.) in the body-wall, whose thickened, pigmented walls are separated from the surrounding tissue by crescentic clefts. Beneath each pit is a closed lacunar space.</td></tr>
</table>

SUMMARY—(*continued*).

	H. floridana Pourtalés	*H. atra* Jäger
Body-wall	Firm; mean thickness, 4 mm. in adult and 1·5 mm. in young. More variable in the adult but, in general, "thick skinned."	Flaccid; mean thickness 1·6 mm. in both adult and young. In general, "thin skinned."
Rosettes	Stellate, central rod short, branches swollen at ends. Growth-stages of the perforated plates.	Central rod somewhat elongated, branches more nearly at right angles. Longer and more delicate.
Perforated plates and rosettes with holes	(1) Developmental stages; *Type a*, 4 holes; *Type b*, 8 holes. (2) Developed plates; mean number of holes, 13 in bivium; 15 in trivium. With age, holes fill up with lime.	Of the statistical series of 300 rosettes and rosettes with holes, 2 had 3 holes, 4 had 2 holes and 19 had 1 hole. Rare variates may have more holes (up to 6) but such perforated plates are not like the developed perforated plates of *H. floridana*. Occasional elongated "Buttons" occur with 2 pairs of central holes and 1 distal hole at each end.
Average number of peripheral holes in discs of tables	5·2	3·7.
Number of rosettes and perforated plates per sq. cm.	5,000,000 to 12,000,000	50,000.
Pedicels and papillae in bivium	Large majority cylindrical and with suckers are pedicels. 1 out of 16, papillae.	Majority conical and without suckers are papillae.
Types of end-plates	In bivium, *A* (47°/₀), *B* (41°/₀), *C* (9°/₀), and *D* (1°/₀). In trivium, *A* (92°/₀), *B* (6°/₀) and *C* (2°/₀). Mean diameters of all types larger than in *H. atra*.	In bivium, *A* (·5°/₀), *B* (44°/₀), *C* (34°/₀), *D* (11°/₀) and *E* (4°/₀). In trivium, *A* (72°/₀), *B* (19°/₀), *C* (6°/₀), *D* (2°/₀) and *E* (2°/₀). Only 1 in bivium large enough to be placed in *Type A*.
Polian vesicles	Simple, or branched; solitary, or in tufts; mean number, in adult, 13, with range of 1—92. 74°/₀ of young with 1 vesicle. Branching and formation of tufts due to growth.	Simple; mean number; in adult, 21, with range of 1—56; in young, 10, with range of 4—24.
Stone-canals Mean total number in adult	37, with range of 1—149. 54°/₀ more than *H. atra*.	24, with range of 15—70.
Mean average length in adult	5 mm.	7 mm. 40°/₀ longer than in *H. floridana*.

B. Characters Common to the Two Species.

Dimensions.—In both adult and young the standard deviation is least in the diameter, greater in the length and greatest in the volume. The relatively much larger standard deviation in the volume of the adult when compared with that of the young is to be expected because of the limited range of the latter.

Distribution of pedicels and papillae.—In both adult and young the standard deviation in the distribution of these appendages is considerably greater in the trivium.

Tentacles.—Mode, 20. As shown by the average standard deviation of ·7 in adult and young of *H. floridana* and of ·9 in *H. atra* the number of tentacles show but little variation when compared with most of the other characters.

The greater tendency in variation to less than the normal number, probably comes from the loss of tentacles by accident rather than from inherent congenital variation. It is therefore likely that the majority of the small and medium sized tentacles are stages in regeneration.

Variation in the location of the tentacles lying in the dorsal inter-radius with reference to the mesentery attachment is shown in about 20 °/₀ of the specimens.

The tentacular ampullae have branches only in the adult and hence the formation of such branches, when it occurs, comes with advancing age.

Pedicels and papillae defined.—The typical pedicel is cylindrical, with sucker, end-plate of *Type A* or *B*, sometimes with supporting rods different from those of the papilla.

The typical papilla is conical, without sucker, with end-plate of *Type D* or *E* and with supporting rods of its own kind.

The typical pedicels and papillae are connected by a group of appendages not definitely cylindrical or conical, with suckers either present, rudimentary or absent, having end-plates of *Type C* and with supporting rods either present or absent.

End-plates.—Standard deviation much the largest in *Type A*, decreasing relatively less and less with each succeeding type.

Supporting rods:—in papillae and tentacles; straight or curved rib-like rods with ends spinose, branched, or expanded, and with 1 to several holes.

In pedicels.—Straight, or slightly curved, rods with a hole in each expanded end. Sometimes with branched ends and several holes. Connecting links to the perforated plates of the body-wall may be found towards the base of the pedicel.

Tables.—The table developes from a short rod with forked ends. These ends divide and the recurved branches from either end grow together and fuse, forming the 4 larger primary holes of the centre of the disc. Then 4 smaller secondary, and often still smaller tertiary, peripheral holes are formed as the disc is completed. At the same time the vertical rods arise and then are bound together

distally by transverse beams to form the spire and crown. At the last, from each corner, 3 teeth are developed, 2 horizontal diverging at right angles and the 3rd perpendicular to the plane of the others. The characters of the table show increasing variability in the following order, arranged according to the average of the standard deviations in adult and young, given after each character :—

Number of teeth on crown (1·1), number of spines on disc (1·4), diameter of hole in crown (2·1), number of peripheral holes in disc (2·3), diameter of crown, not including teeth (2·4), diameter of crown including teeth (5·5), diameter of disc (5·6), and height of table (9·4). The tables in the bivium have more peripheral holes, spines, and teeth, broader crown, larger crown-hole and longer teeth than in the trivium, although the difference in some of these characters is very small.

The average mean number of spines on the disc of the table in both bivium and trivium is ·6 in *H. floridana* and ·7 in *H. atra* while 80 °/₀ of the former and 82 °/₀ of the latter are without spines. Thus it is clearly apparent that the possession of spines is not a differential character for either species, and in connection with the much discussed variety *amboinensis* of Semper is of no importance whatever.

Rosettes.—Standard deviation slightly larger in the greater than in the smaller diameter.

Calcareous ring.—The pieces of the calcareous ring are more regular and delicate in the young. A variation of the radiale is found with notches toward the sides of the anterior margin.

Polian vesicles and stone-canals.—Increase in number and length with the growth of the animal.

C. Additional Characters of H. floridana.

Growth.—The embryo during the 5th day after fertilization and still within the vitelline membrane is ·33 mm. in length, ·28 mm. in diameter and ·0102 cm.³ in volume. In the 75th day it is 4 mm. in length, ·95 mm. in diameter and 1·4175 cm.³ in volume.

Adopting a volume of 50 cm.³ as the limit in size of the fully developed young, this group averages 7 cm. in length, 2 cm. in diameter and 13 cm.³ in volume.

The adult average 18 cm. in length, 5 cm. in diameter and 210 cm.³ in volume. The greatest length is 33 cm., the greatest diameter 8 cm., and the greatest volume 885 cm.³

Tentacles.—20 °/₀ have less, and only 6 °/₀ more, than the mode of 20.

Development of tentacles.—In relation to their origin from the radial canals, the 4 primitive tentacles of the 4th day embryo are *d*1, left dorsal; *d*1 right ventral; *r*1, mid-ventral and *d*1, left ventral (cf. Scheme of Symmetry, Fig. A, Pl. V).

The remaining tentacles, so far as my series from the embryo extends, arise in the following order.—5th, *l*1, mid-ventral; 6th, *d*2, right ventral; 7th, *d*2, left ventral; 8th, *d*1, right dorsal; 9th and 10th, either *v*1 of right or left dorsal; 11th, *r*2, mid-ventral; 12th, *l*2, mid-ventral, and 13th, *d*2, left dorsal.

The tentacle ampullae have branches in 15 % of the specimens.

Development of pedicels and papillae.—The 1st pedicel buds from the posterior end of the mid-ventral radial canal in the 4th day. The next 3 arise from and *always to the left* of the mid-ventral radial canal and not until the 40th day does a pedicel appear *to the right* from this radial canal. The 1st pair of papillae appears on the 24th day ventrad from the anterior ends of the dorsal radial canals and will become warts. On the 30th day the 1st pair of pedicels appears from the lateral ventral radial canals. Gradually the number increases until the 75th day when there are 30 developed and 68 buds, mostly arranged in bilateral rows. The smallest of the fully-developed young has 77 developed pedicels and papillae in rows but later on the inter-radial regions of the adult show evenly distributed appendages.

Anal papillae.—In 5 groups in a majority of the specimens.

Spicules.—The rosettes are characteristic of the young and the perforated plates of the adult. The average of the standard deviations in number of holes in the dorsal and ventral rosettes with holes is 1·5.

Perforated plates.—Averages of the standard deviations of each character in bivium and trivium have the following order:—

a. Developmental stages;—number of holes (1·0), width (2·8) and length (3·0).

b. Developed plates;—Width (2·6), length (3·1) and number of holes (3·4).

Polian vesicles.—The standard deviation of the number of vesicles and branches is greater than that of the greatest length in the adult, and the reverse is true in the young. The variability in the number of vesicles and branches in the adult is 6 times that of the young and in the greatest length, twice that of the young.

Stone-canals.—The standard deviations of the various characters increase in the following order:—*Adult*, average length (1·7); greatest length (4·1); number, left (11·8), right (15·9), total (24·7): *Young*, average length (1·4), greatest length (2·2), number, left (2·5), right (4·0), total (6·0).

D. Additional Characters of H. atra.

Dimensions.—The young average 8 cm. in length, 2 cm. diameter and 20 cm.^{3} volume.

The adult average 16 cm. in length, 5 cm. in diameter and 170 cm.^{3} in volume. The greatest length is 33 cm. The greatest diameter 8 cm. and the greatest volume 538 cm.^{3}

Tentacles.—35 °/₀ have less and only 5 °/₀ more than the mode of 20.

In one case, the largest adult, the tentacular ampullae have 25 branches.

Anal papillae.—Indefinitely distributed in a majority of the specimens.

Supporting rosettes or plates.—Are found in the wall of the sucker, near the end-plate of the pedicel.

Rosettes with holes.—Average standard deviation in number of holes ·5.

Polian vesicles.—In the adult the standard deviation of the number of vesicles and branches (19·6) is over twice that of the greatest length (8·4). In the young (6·1) it is slightly greater than that of the greatest length (5·4).

Stone-canals.—The standard deviations of the various characters increase in the following order:—*Adult*, number, right (1·0), average length (2·2), greatest length (3·8), number, left (9·0), total (15·0):—*Young*, number, left (1·6), average length (1·7), greatest length (1·7), number, right (3·3), total (4·8).

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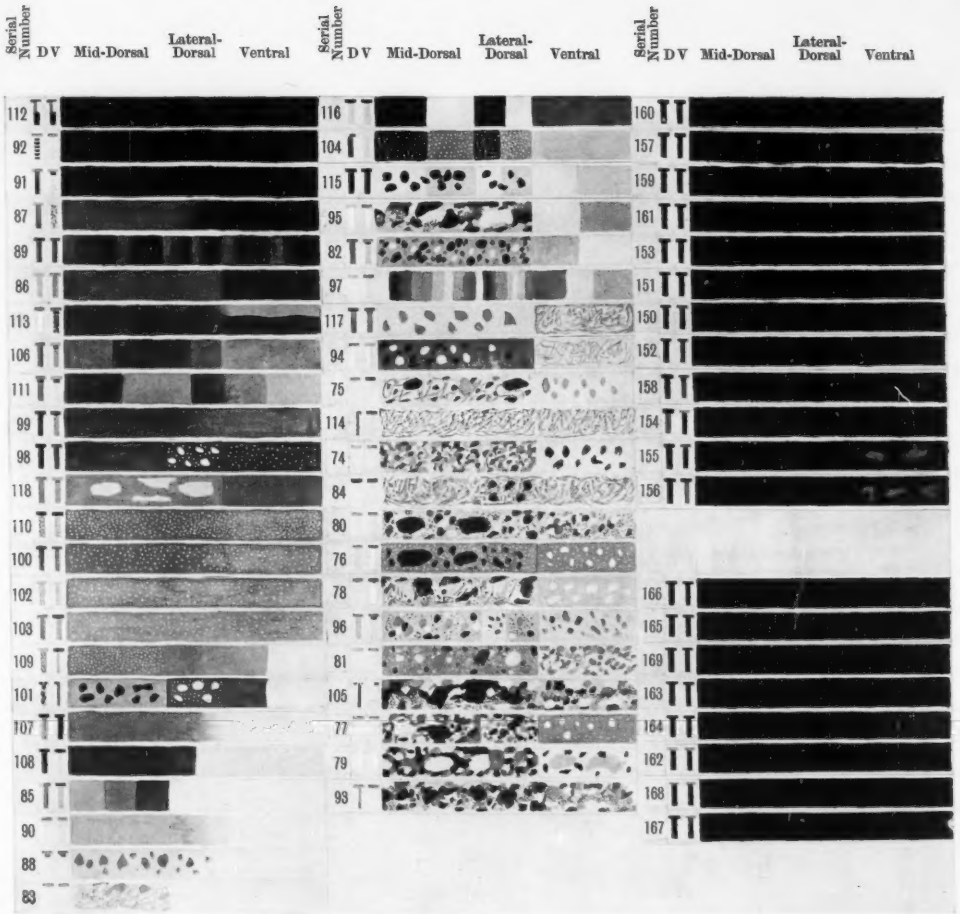
EXPLANATION OF PLATES.

PLATE I. Colour variation in the young of *H. floridana* Pourtalés (112—93) and of the adult (160—156) and young (166—167) of *H. atra* Jäger. The ambulacral appendages (pedicels and papillae) and the regions of the body are represented in a diagrammatic form for each individual of the statistical series as numbered in the column to the left. The appendages under D are dorsal and under V, ventral. The stalk and usually expanded terminal end of each appendage and the various regions of the surface of the body show the average colouration and its distribution for the respective parts. The colours, "browns," "creams," "grays," black and white, are given as they occur in dots, spots and blotches upon the general background, or else as uniform for the whole body, or its different regions. The plate does not always give exactly the colour effects of the original water-colours as described in the text. The predominant tint in 160—167 is seal-brown rather than violet-brown. The violet tone also has modified the grays and creams in 112—93. In 112, 92, and the ventral region of 91, the tint should be clove-brown.

PLATE II. Colour variation in the adult of *Holothuria floridana* Pourtalés. General explanation as given for Plate I. The original colours resemble those in Plate I as qualified in the above explanation. The colour values are not fully reproduced in the half-tone for the dark shades are browns that range from seal, Vandyke, sepia, and other tints, to clove-brown and black instead of having the uniformity represented.

PLATE III. Papilla, pedicel and their calcareous spicules.
FIGS. 10, 11, 13, 17—22 from *H. floridana*; 1—9, 12, 14—16 from *H. atra*.
FIGS. 1, 3, 5—13 dorsal; 2, 4, 14—22 ventral.
FIGS. 1—9, $\times 55\frac{1}{3}$; 10—22, $\times 260$.
FIG. 1. Papilla with supporting rods and *type E* end-plate.
FIG. 2. Pedicel with supporting rods, sucker, and *type A* end-plate in profile.
FIG. 3. *Type A*, end-plate.
FIG. 4. *Type A* end-plate with larger holes toward the centre.
FIG. 5. *Type B* end-plate.
FIG. 6. *Type C* end-plate.
FIG. 7. *Type C* end-plate with larger, irregular holes.
FIG. 8. *Type D* end-plate.
FIG. 9. *Type E* end-plate.
FIGS. 10—12. Variation types of dorsal supporting rods.
FIG. 10. Nearly straight with ends spinous.
FIG. 11. Arcuate with spinous ends branched.
FIG. 12. Expanded ends spinous, branched and perforated.
FIG. 13. Rare dorsal supporting rosette.
FIG. 14. Ventral supporting plate.
FIGS. 15, 16. Ventral supporting rosettes with broadly branched perforated ends.
FIGS. 17—22. Series of ventral supporting rods, nearly straight with more or less expanded, branched and perforated ends (Figs. 20—22) leading through connecting links (Figs. 18, 19) to the perforated plate (Fig. 17) characteristic of the body-wall.

PLATE IV. Calcareous spicules of the body-wall; their form, size, development and variation.
FIGS. 23—45, 47, 49, 50, 53, 55—60, 62—66, 68—70, 73, from *H. floridana*; 23—27 f., 46, 48, 51, 52, 54, 61, 67, 71, 72, 74, from *H. atra*.
FIGS. 24, 28—36, 38, 42—45, 47—51, 53—66, 68—70, 73, dorsal; 23, 25—27 f., 37, 39—41, 46, 52, 67, 71, 72, 74, ventral. All figures $\times 260$.
FIGS. 23—26 rosettes; 26—27 f. rosettes with holes and perforated plates of *H. atra*.
FIGS. 28—33, 35 rosettes and developmental stages of perforated plates; 34, 36—41 perforated plates of *H. floridana*; 37, developmental *Type a*; 38, developmental *Type b*; 38a, *Type b*, incomplete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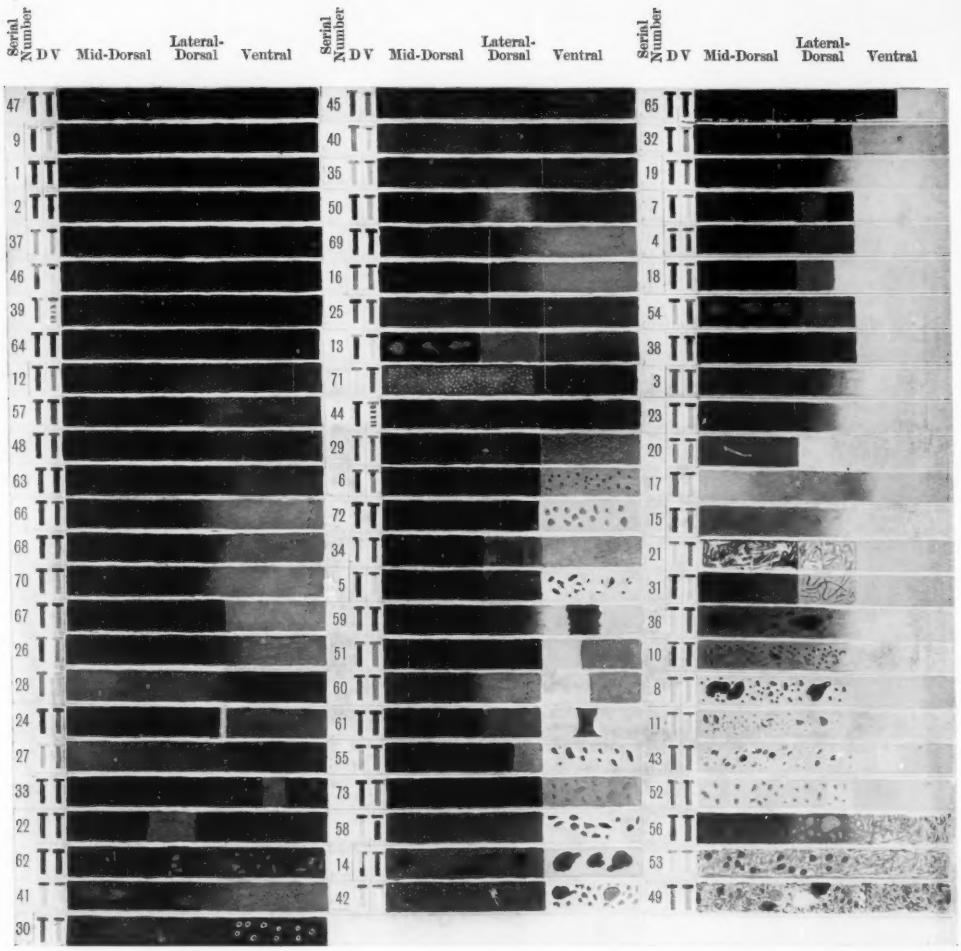
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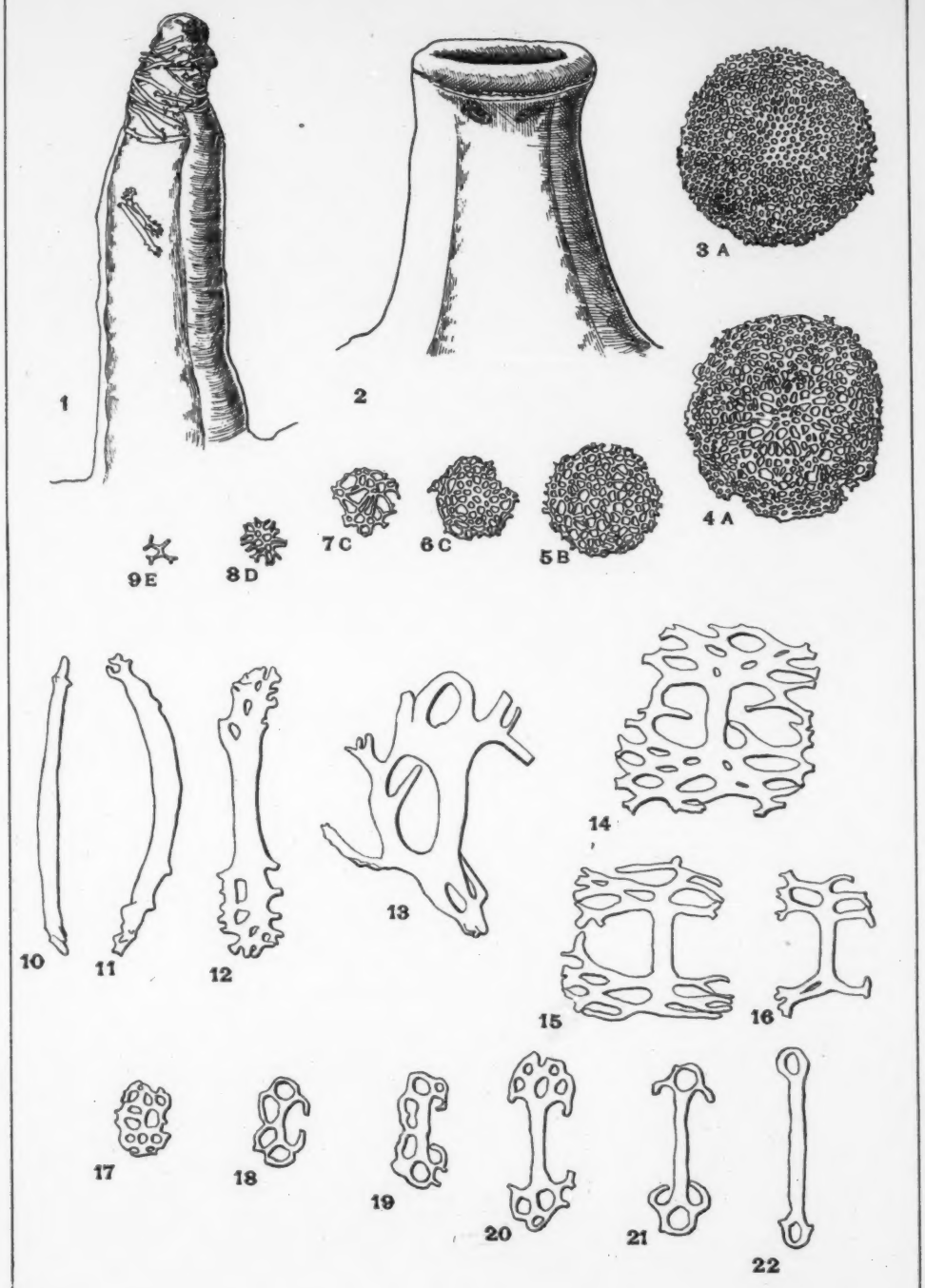
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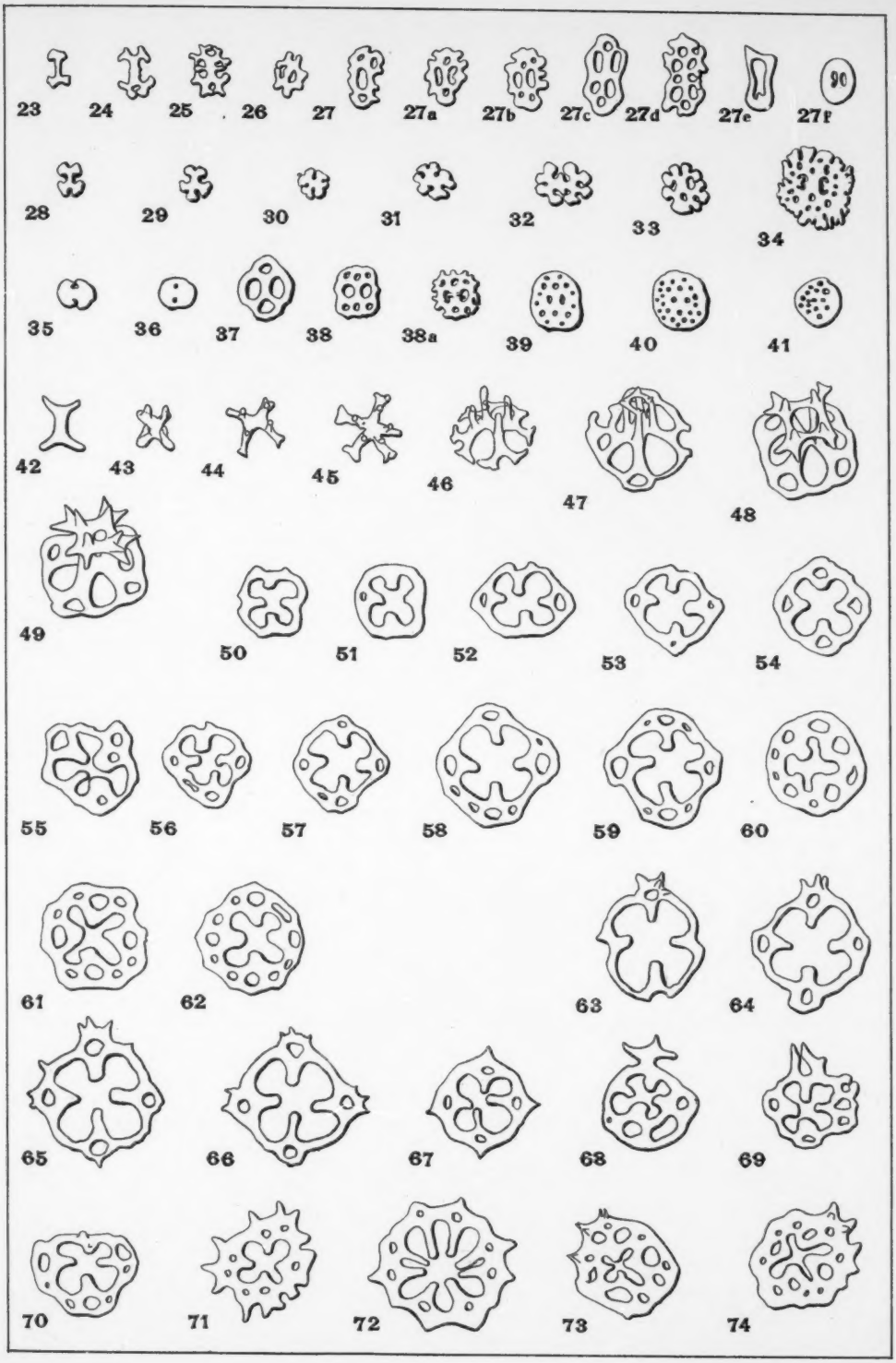
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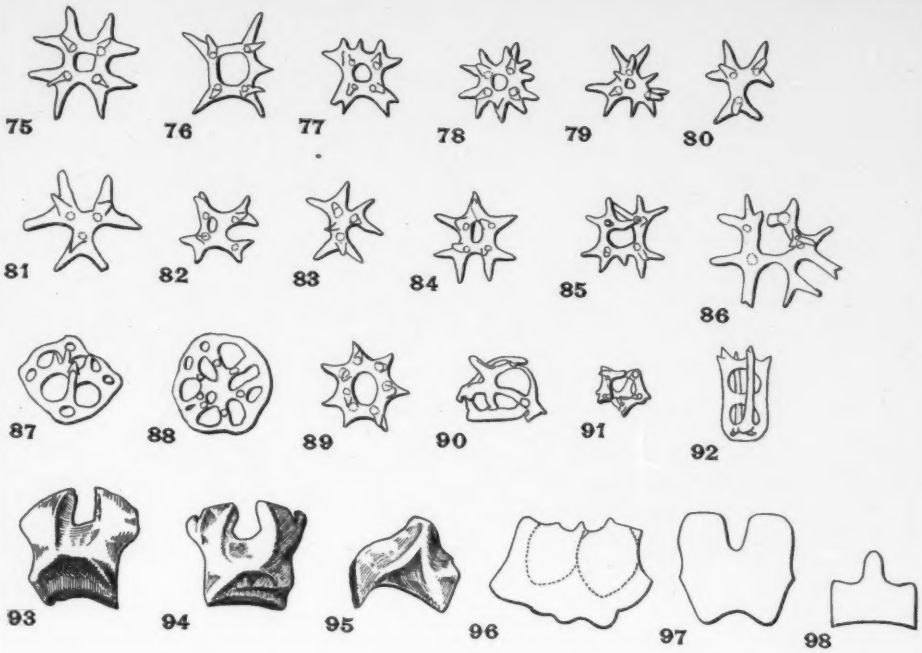
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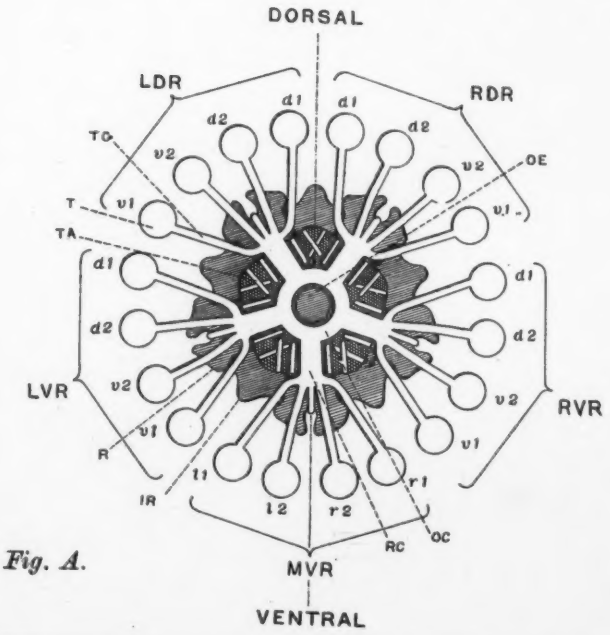
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OC
MVR
VENTRAL

Fig. A.

and in process of growth; 36, 39—41, completely developed plates, the holes filling with lime until in 41 over $\frac{2}{3}$ of the holes have become filled to pits (indicated by shading); 34, incomplete plate of large size. In 34, 39, 40 the basic developmental *Types a* and *b* may be noted surrounded with additional peripheral holes.

FIGS. 42—49 illustrate the development of the table.

FIG. 42. Rod with forked end, Anlage of disc.

FIG. 43. Appearance of the 4 vertical rods.

FIG. 44. Ends of the 4 prongs begin forking.

FIG. 45. Variate with 5 prongs and 5 vertical rods.

FIG. 46. Formation of primary and peripheral holes of disc and growth of vertical rods.

FIG. 47. The 4 primary and 2 of the secondary holes completed; joining of vertical rods by transverse beams to form crown; appearance of teeth.

FIG. 48. Nearly developed table.

FIG. 49. Fully developed table.

FIGS. 50—62. Series of disc variates. To show the feature of the disc each is drawn with the vertical rods bearing the crown removed at their bases. Figs. 50—54 have the 4 primary holes indicated with developing secondary holes as follows: 50, none; 51, 1; 52, 2; 53, 3; 54, 4.

FIGS. 55—62 show variation in the number of peripheral holes (secondary and tertiary) from 4—11.

FIGS. 63—74. Series of discs (drawn as above) showing variation in the number (1—10), form and size of spines, accompanied by a modal distribution of holes (64—67) or by an abnormal number and distribution of holes (63, 68—74). In 72, with a nearly circular disc, there are 8 vertical rods with a secondary hole for each rod.

PLATE V. Calcareous spicules of the body-wall and the pieces of the calcareous ring.

FIGS. 77, 78, 80, 83, 85, 87, 90—98 from *H. floridana*; 75, 76, 79, 81, 82, 86, 88, 89 from *H. atra*.

FIGS. 77, 78, 80, 83—85, 87, 90—92 dorsal; 75, 76, 79, 82, 86, 88, 89 ventral.

FIGS. 75—92, $\times 260$; Figs. 93—96, $\times 2\frac{1}{2}$; 97, 98, $\times 9\frac{1}{2}$.

FIGS. 75—86. Series of crown variates. The underlying vertical rods are indicated by dotted outlines. Fig. 75, normal type with 12 teeth; 76, 2 teeth at each of 3 corners, 3 at the 4th and 1 on a transverse bar; 77, extra tooth on a transverse bar; 78, 3 extra teeth on transverse bars; 79, triangular variate with extra tooth on each of 3 transverse bars; 80, incomplete crown, 1 corner lacking; 81, triangular variate without central hole; 82—84, abnormal variates; 85, incomplete crown from the failure to fuse of the two processes which would normally make a transverse bar; 86, incomplete crown with some teeth lacking, 2 bifid and 1 extra vertical rod.

FIG. 87. Complete disc, 5 vertical rods and no crown.

FIG. 88. Disc and 89 crown, of table with 7 vertical rods.

FIG. 90. Disc and 91 crown, of abnormal variate.

FIG. 92. Reduced table with only central part of disc and the spire present.

FIGS. 93—96 from calcareous ring of the adult.

FIG. 93. Radiale, usual form.

FIG. 94. Radiale, with anterior border notched toward the sides.

FIG. 95. Inter-radiale.

FIG. 96. Fused ventral and left ventral radialia, the intervening left ventral inter-radiale included in the compound piece.

FIGS. 97, 98. More regular and delicate pieces of the calcareous ring of the young.

FIG. 97. Radiale.

FIG. 98. Inter-radiale.

FIG. A. See for explanation p. 248.

PROBABLE ERROR OF A CORRELATION COEFFICIENT.

By STUDENT.

At the discussion of Mr R. H. Hooker's recent paper "The correlation of the weather and crops" (*Journ. Royal Stat. Soc.* 1907) Dr Shaw made an enquiry as to the significance of correlation coefficients derived from small numbers of cases.

His question was answered by Messrs Yule and Hooker and Professor Edgeworth, all of whom considered that Mr Hooker was probably safe in taking ·50 as his limit of significance for a sample of 21. They did not, however, answer Dr Shaw's question in any more general way. Now Mr Hooker is not the only statistician who is forced to work with very small samples, and until Dr Shaw's question has been properly answered the results of such investigations lack the criterion which would enable us to make full use of them. The present paper, which is an account of some sampling experiments, has two objects: (1) to throw some light by empirical methods on the problem itself, (2) to endeavour to interest mathematicians who have both time and ability to solve it.

Before proceeding further, it may be as well to state the problem which occurs in practice, for it is often confused with other allied questions.

A random sample has been obtained from an indefinitely large* population and r† calculated between two variable characters of the individuals composing the sample. We require the probability that R for the population from which the sample is drawn shall lie between any given limits.

It is clear that in order to solve this problem we must know two things: (1) the distribution of values of r derived from samples of a population which has a given

* Note that the indefinitely large population need not actually exist. In Mr Hooker's case his sample was 21 years of farming under modern conditions in England, and included all the years about which information was obtainable. Probably it could not actually have been made much larger without loss of homogeneity, due to the mixing with farming under conditions not modern; but one can imagine the population indefinitely increased and the 21 years to be a sample from this.

† Throughout the rest of this paper "r" is written for the correlation coefficient of a sample and R for correlation coefficient of a population.

R, and (2) the *à priori* probability that R for the population lies between any given limits. Now (2) can hardly ever be known, so that some arbitrary assumption must in general be made; when we know (1) it will be time enough to discuss what will be the best assumption to make, but meanwhile I may suggest two more or less obvious distributions. The first is that any value is equally likely between $+1$ and -1, and the second that the probability that x is the value is proportional to $1-x^2$: this I think is more in accordance with ordinary experience: the distribution of *à priori* distribution would then be expressed by the equation $y=\frac{3}{4}(1-x^2)$.

But whatever assumption be made, it will be necessary to know (1), so that the solution really turns on the distribution of r for samples drawn from the same population. Now this has been determined for *large* samples with as much accuracy as is required, for Pearson and Filon (*Phil. Trans.* Vol. 191 A, p. 229 *et seq.*) showed that the standard deviation is $\frac{1-r^2}{\sqrt{n}}$ and of course for large samples the distribution is sure to be practically normal unless r is very close to unity. But their method involves approximations which are not legitimate when the sample is small. Besides this the distribution is not then normal, so that even if we had the standard deviation a great deal would still remain unknown.

In order to throw some light on this question I took a correlation table* containing 3000 cases of stature and length of left middle finger of criminals, and proceeded to draw samples of four from this population†. This gave me 750 values of r for a population whose real correlation was ·66. By taking the statures of one sample with the middle finger lengths of the next sample I was enabled to get 750 values of r for a population whose real correlation was zero. Next I combined each of the samples of four with the tenth sample before it and with the tenth sample after it, thus obtaining two sets of 750‡ values from samples of 8, with real correlation ·66 and zero.

Besides this empirical work it is possible to calculate *à priori* the distribution for samples of two as follows.

For clearly the only values possible are $+1$ and -1, since two points must always lie on the regression line which joins them§.

Next consider the correlation between the difference between the values of one character in two successive individuals, and the difference between the values of the other character in the same individuals. It is well known to be the same as that between the values themselves, if the individuals be in random order.

* *Biometrika*, Vol. I. p. 219. W. R. Macdonnell. † *Biometrika*, Vol. VI. p. 13. Student.

‡ Not strictly independent, but practically sufficiently nearly so. This method was adopted in order to save arithmetic.

§ There are of course indeterminate cases when the values are the same for one character, but they become rarer as we decrease the unit of grouping until with an infinitesimal unit of grouping the statement in the text is true.

Also, if an indefinitely large number of such differences be taken, it is clear that the means of the distributions will have the value zero. Hence, if the correlation be determined from a fourfold division through zero we can apply Mr Sheppard's* result that if A and B be the numbers in the large and the small divisions of the table respectively $\cos\frac{\pi B}{A+B}=R$, where R is the correlation of the original system.

But if a pair of individuals whose difference falls in either of the small divisions be considered to be a random sample of 2, their r will be found to be -1, while that of a pair whose difference falls in one of the large divisions is $+1$. Hence the distribution of r for samples of 2 is AN at $+1$, and BN at -1, where $A+B=1$, and $B=\frac{\cos^{-1}R}{\pi}$.

When $R=0$, there is of course even division, half the values being $+1$, and half -1; when $R=\cdot66$, $B=\frac{\cos^{-1}\cdot66}{\pi}=\cdot271$, therefore $A=\cdot729$, and the mean is at $\cdot729-\cdot271=\cdot458$. The S.D. $=\sqrt{1-(\cdot458)^2}=\cdot889$. It is noteworthy that the mean value is considerably less than R.

I have dealt with the cases of samples of 2 at some length, because it is possible that this limiting value of the distribution with its mean of $\frac{2}{\pi}\sin^{-1}R$ and its second moment coefficient of $1-\left(\frac{2}{\pi}\sin^{-1}R\right)^2$ may furnish a clue to the distribution when n is greater than 2.

Besides these series, I have another shorter one of 100 values of r from samples of 30, when the real value is ·66. The distributions of the various trials are given in the table.

Several peculiarities will be noticed which are due to the effects of grouping, particularly in the samples of 4. Firstly, there is a lump at zero; with such small numbers zero is not an uncommon value of the product moment and then, whatever the values of the standard deviations, $r=0$.

Next there are five indeterminate cases in each of the distributions for samples of 4. These are due to the whole sample falling in the same group for one variable. In such a case, both the Standard Deviation and the product moment vanish and r is indeterminate.

Lastly, with such small samples one cannot use Sheppard's corrections for the Standard Deviations, as r often becomes greater than unity. So I did not use the corrections except in the case of the samples of 30, yet on the whole the values of the Standard Deviations are no doubt too large. This does not much affect the values of r in the neighbourhood of zero, but there is a tendency for larger values

* *Phil. Trans.* A. Vol. CXCII. p. 141.

Distribution of Correlation Coefficients.

Scale	−1·00 – ·98	−·97 – ·93	−·92 – ·88	−·87 – ·83	−·82 – ·78	−·77 – ·73	−·72 – ·68	−·67 – ·63	−·62 – ·58	−·57 – ·53	−·52 – ·48	−·47 – ·43	−·42 – ·38	−·37 – ·33	−·32 – ·28	−·27 – ·23	−·22 – ·18	−·17 – ·13	−·12 – ·08	−·07 – ·03	−·02 + ·02	+·03 + ·07	+·08 + ·12	+·13 + ·17	+·18 + ·22	+·23 + ·27	+·28 + ·32	+·33 + ·37	+·38 + ·42	+·43 + ·47	+·48 + ·52	+·53 + ·57	+·58 + ·62	+·63 + ·67	+·68 + ·72	+·73 + ·77	+·78 + ·82	+·83 + ·87	+·88 + ·92	+·93 + ·97	+·98 + 1·00
No correlation, Samples of 4*	8	17	16	23	13	23	9½	19½	19	17	23	18½	25½	15	22	22	19	19½	23½	15	30	18	14	22	22	22½	24	13½	17	23	24	24½	9½	17½	17½	11½	12½	9	22½	13½	9
No correlation, Samples of 8	1	—	—	1	7	10	10	15	14	15	18	24	18	27	36	33	43	45	26½	26½	34	42½	27½	34	23½	36½	33½	28½	19	24	22	15	13½	9	2½	7	5	3	—	—	—
Correlation of ·66 Samples of 4†	3	3½	2½	2	2	8	3½	1½	5	9	8	7	3	1	4	10	5	5	3	6	16	4	7	9	11	8	14	11	20½	18	30	23½	27	33½	45½	39½	41	80½	64	91	59
Correlation of ·66 Samples of 8	—	—	—	—	—	—	—	—	—	2	—	2	—	3	—	3	6	4	3	4	5	7	7	5	11	17	20	17	22	34	46½	44½	61	59	66½	56½	80½	60	66	33½	4

Scale	·26 to ·28	·29 to ·31	·32 to ·34	·35 to ·37	·38 to ·40	·41 to ·43	·44 to ·46	·47 to ·49	·50 to ·52	·53 to ·55	·56 to ·58	·59 to ·61	·62 to ·64	·65 to ·67	·68 to ·70	·71 to ·73	·74 to ·76	·77 to ·79	·80 to ·82	·83 to ·85
Distribution with samples of 30	1	—	—	1	—	1	—	1	6	4	5	9	12	10	15	12	7	10	5	1

* There are five indeterminate cases so that the total is 745, while there are 750 in the other two distributions.

† The moment coefficients of this distribution were actually calculated from a different grouping as below:

−1·00 – ·95	−·94 – ·90	−·89 – ·85	−·84 – ·80	−·79 – ·75	−·74 – ·70	−·69 – ·65	−·64 – ·60	−·59 – ·55	−·54 – ·50	−·49 – ·45	−·44 – ·40	−·39 – ·35	−·34 – ·30	−·29 – ·25	−·24 – ·20	−·19 – ·15	−·14 – ·10	−·09 – ·05	−·04 – ·00	+·01 + ·05	+·06 + ·10	+·11 + ·15	+·16 + ·20	+·21 + ·25	+·26 + ·30	+·31 + ·35	+·36 + ·40	+·41 + ·45	+·46 + ·50	+·51 + ·55	+·56 + ·60	+·61 + ·65	+·66 + ·70	+·71 + ·75	+·76 + ·80	+·81 + ·85	+·86 + ·90	+·91 + ·95	+·96 + 1·00
5	4	2	2	6	4	3	4	7	9	7	5	1	2	6	7	7	5	4	18	2	5	11	8	12	12½	7½	17	21	24	20	35	31	35	50	34	58½	78	77	98½

to come too low, so that there is a deficiency of cases towards 1 and -1. This introduces an error into the Standard Deviation of all the series to some extent, but of course the mean is unaltered when there is no correlation. The series for samples of 4 are affected more than those from samples of 8, as the mean Standard Deviation of samples of 4 is the smaller, so that the unit of grouping is comparatively larger.

The moment coefficients of the five distributions were determined, and the following values found*:—

	Mean	S.D.	μ_2	μ_3	μ_4	β_1	β_2
Samples of 4 ($r=0$)	—	·5512	·3038	—	·1768	—	1·918
Samples of 8 ($r=0$)	—	·3731	·1392	—	·0454	—	2·336
Samples of 4 ($r=·66$)	·5609	·4680	·2190	−·1570	·2152	2·245	4·489
Samples of 8 ($r=·66$)	.6139	·2684	·07202	−·02634	·02714	1·857	5·232
Samples of 30 ($r=·66$)	·661	·1001	·01003	−·000882	·000461	·7713	4·580

Considering first the "no correlation" distributions I attempted to fit a Pearson curve to the first of them. As might be expected, the range proved limited and as symmetry had been assumed in calculating the moments, a Type II curve resulted. The equation was $y = y_0\left(1-\frac{x^2}{1{\cdot}076}\right)^{\cdot 272}$, the range of which is 2·074.

Now the real range is clearly 2, and only a very small alteration in β_2 is required to make the value of the index zero. Consequently the equation $y = y_0(1-x^2)^0$ was suggested. This means an even distribution of r between 1 and -1, with S.D. $= ·5774 \pm ·010$ vice ·5512 actual, $\mu_2 = ·3333 \pm ·0116$ vice ·3038, $\mu_4 = ·2000 \pm ·016$ vice ·1768 and $\beta_2 = 1·800 \pm ·12$ vice 1·918, all values as close as could perhaps be expected considering that the grouping must make both μ_2 and μ_4 too low.

Working from $y = y_0(1-x^2)^0$ for samples of 4 I guessed the formula $y = y_0(1-x^2)^{\frac{n-4}{2}}$ and proceeded to calculate the moments.

By using the transformation $x = \sin\theta$ we get $y = y_0\cos^{n-4}\theta$,

$$dx = \cos\theta\, d\theta,$$

$$2\int_0^1 y\,dx = 2y_0\int_0^{\frac{\pi}{2}} \cos^{n-2}\theta\, d\theta,$$

$$2\int_0^1 x^2 y\,dx = 2y_0\int_0^{\frac{\pi}{2}} \cos^{n-3}\theta\, d\theta - 2y_0\int_0^{\frac{\pi}{2}} \cos^{n-1}\theta\, d\theta,$$

and so on.

Whence

$$\mu_2 = \frac{1}{n-1}, \qquad \mu_4 = \frac{3}{(n-1)(n+1)}, \qquad \beta_2 = \frac{3(n-1)}{n+1} = 3 - \frac{6}{n+1}.$$

* In the cases of no correlation the moments were taken about zero, the known centroid of the distribution.

Putting $n=8$ we get the equation $y=y_0(1-x^2)^2$ and

$\mu_2=\frac{1}{7}=\cdot1429\pm\cdot0050$ instead of actual $\cdot1392$,

$\mu_4=\frac{1}{21}=\cdot0476\pm\cdot0038$ " " $\cdot0454$,

$\sigma=\cdot3780\pm\cdot0066$ " " $\cdot3731$,

$\beta_2=3-\frac{6}{9}=2\cdot333\pm\cdot012$ " " $2\cdot336$.

The equation calculated from the actual moments is $y=y_0\left(1-\frac{x^2}{\cdot9802}\right)^{2\cdot021}$ whence the calculated range is 1·98, whereas it is known to be 2.

The following tables compare the actual distributions with those calculated from the equations.

Distribution of r from samples of 4 compared with the equation $y=\frac{745}{2}(1-x^2)^3$.

	−1 to −·825	−·825 to −·675	−·675 to −·525	−·525 to −·375	−·375 to −·225	−·225 to −·075	−·075 to +·075	+·076 to +·225	+·225 to +·375	+·375 to +·525	+·525 to +·675	+·675 to +·825	+·825 to +1
Actual ...	64	45½	55½	67	59	62	63	58	60	64	51½	41½	54
Calculated	65	56	56	56	56	56	56	56	56	56	56	56	65
Difference	−1	−10½	−½	+11	+3	+6	+7	+2	+4	+8	−4½	−14½	−11

From this we get $\chi^2=13\cdot30$, $P=\cdot34$. It will however be noticed that the grouping has caused all the middle compartments to contain more than the calculated, as pointed out above.

Distribution of r from samples of 8 compared with the equation

$$y=\frac{750\times15}{16}(1-x^2)^3.$$

	−1 to −·825	−·825 to −·675	−·675 to −·525	−·525 to −·375	−·375 to −·225	−·225 to −·075	−·075 to +·075	+·075 to +·225	+·225 to +·375	+·375 to +·525	+·525 to +·675	+·675 to +·825	+·825 to +1
Actual ...	2	27	44	60	96	114½	103	85	98½	65	37½	14½	3
Calculated	4½	20½	43	67	87	100½	105	100½	87	67	43	20½	4½
Difference	−2½	+6½	+1	−7	+9	+14	−2	−15½	+11½	−2	−5½	−6	−1½

whence $\chi^2=13\cdot94$, $P=\cdot30$.

In this case the grouping has had less influence and the largest contributions to χ^2 (in the second, sixth, eighth, and twelfth compartments) are due to differences of opposite sign on opposite sides, and may therefore be supposed to be entirely due to random sampling.

My equation then fits the two series of empirical results about as well as could be expected. I will now show that it is in accordance with the two theoretical cases n "large" and $n=2$, for $\sigma=\dfrac{1}{\sqrt{n-1}}$ which approximates sufficiently closely to Pearson and Filon's $\dfrac{1-r^2}{\sqrt{n}}$ when $r=0$ and n is large. Also when n is large β_2 becomes 3 and the distribution is normal.

And if $n=2$, the equation becomes $y=y_0(1-x^2)^{-1}$* where

$$y_0=\frac{N}{2\int_0^1(1-x^2)^{-1}dx}.$$

Put $x=\sin\theta$. Then $dx=\cos\theta\,d\theta$,

$$y_0=\frac{N}{2}\Big/\int_0^{\frac{\pi}{2}}\sec\theta\,d\theta=\frac{N}{2}\Big/\infty=0,$$

i.e. there is no frequency except where $(1-x^2)^{-1}$ is infinite, all the frequency is equally divided between $x=1$ and $x=-1$ which we know to be actually the case.

Consequently I believe that the equation $y=y_0(1-x^2)^{\frac{n-4}{2}}$ probably represents the theoretical distribution of r when samples of n are drawn from a normally distributed population with no correlation. Even if it does not do so, I am sure that it will give a close approximation to it.

Let us consider Mr Hooker's limit of ·50 in the light of this equation. For 21 cases the equation becomes $\left.\begin{matrix}x=\sin\theta\\ y=y_0\cos^{17}\theta\end{matrix}\right\}$ and the proportion of the area lying beyond $x=\pm\,{\cdot}50$ will be

$$\frac{\int_{\theta=\sin^{-1}\cdot50}^{\theta=\frac{\pi}{2}}\cos^{18}\theta\,d\theta}{\int_0^{\frac{\pi}{2}}\cos^{18}\theta\,d\theta}.$$

I find this to be ·02099, or we may expect to find one case in 50 occurring outside the limits $\pm\,{\cdot}50$ when there is no correlation and the sample numbers 21.

* If a Pearson curve be fitted to the distribution whose moment coefficients are $\mu_3=1=\mu_4$ and $\mu_3=0$ we have $\beta_2=1$, $\beta_1=0$, hence the curve must be of Type II. and the equation is given by

$$y=y_0\left(1-\frac{x^2}{a^2}\right)^m \text{ where } a^2=\frac{2\mu_2\beta_2}{3-\beta_2}=1 \text{ and } m=\frac{5\beta_2-9}{2(3-\beta_2)} \text{ or } y=y_0(1-x^2)^{\frac{n}{2}-1},$$

agreeing with the general formula.

When however there is correlation, I cannot suggest an equation which will accord with the facts, but as I have spent a good deal of time over the problem I will point out some of the necessities of the case.

(1) With small samples the value certainly lies nearer to zero than the real value of R, *e.g.*

samples of 2: mean at $\frac{2}{\pi}\sin^{-1}R$,

samples of 4 (real value ·66) ·561* ± ·011,

samples of 8 (real value ·66) ·614† ± ·065.

But with samples of 30 (real value ·66) mean at ·6609 ± ·0067 shows that the mean value approaches the real value comparatively rapidly.

(2) The standard deviation is larger than accords with the formula $\frac{1-r^2}{\sqrt{n-1}}$ even if we give the mean value of r for samples of the size taken, *e.g.* for samples of 2,

$$\text{S.D.} = \sqrt{1-\left(\frac{2}{\pi}\sin^{-1}R\right)^2}.$$

For samples of 4, calculated‡ ·3957 ± ·0069; actual ·4680,

„ „ 8 „ ·2355 ± ·0041; actual ·2684.

But samples of 30 calculated ·1046 ± ·0018, actual ·1001, again show that with samples as large as 30 the ordinary formula is justified.

(3) When there was no correlation the range found by fitting a Pearson curve to the distribution was accurately 2 in the theoretical case of samples of two, and well within the probable error for empirical distributions of samples of 4 and 8. But when we have correlation this process does not give the range closely for the empirical distribution (samples of 4 give 2·137, samples of 8 2·699, samples of 30 infinity) and the range calculated from samples of 2, which is

$$\frac{2\sqrt{4+3\mu_2+18\mu_2^2-9\mu_2^3}}{3+\mu_2},$$

$\left(\text{where } \mu_2 = 1-\left(\frac{2}{\pi}\sin^{-1}R\right)^2\right)$ is always less than 2 except in the case where μ_2 is 1, *i.e.* when there is no correlation.

Hence the distribution probably cannot be represented by any of Prof. Pearson's types of frequency curve unless $R=0$.

(4) The distribution is skew with a tail towards zero.

* The value must be slightly larger than this (perhaps even by ·03) as Sheppard's corrections were not used.

† Again higher, but not by more than ·02.

‡ $\frac{1-r^2}{\sqrt{n-1}}$ where r is taken as the mean value for the size of the sample. If we took the real value R, the difference would be even greater.

(5) To sum up:—If $y = \phi(x, R, n)$ be the equation, it must satisfy the following requirements. If $R = 1$, 1 is the only value of x which gives the value of y other than zero. If $n = 2, \pm 1$ are the only values of x to do so. If $R = 0$ the equation probably reduces to $y = y_0(1 - x^2)^{\frac{n-4}{2}}$.

Conclusions.

It has been shown that when there is no correlation between two normally distributed variables $y = y_0(1 - x^2)^{\frac{n-4}{2}}$ gives fairly closely the distribution of r found from samples of n.

Next, the general problem has been stated and three distributions of r have been given which show the sort of variation which occurs. I hope they may serve as illustrations for the successful solver of the problem.

ZUR FRAGE VOM VIERGLIEDERIGEN TARSUS DER BLATTIDAE UND DER REGENERATION DER FÜSSE DERSELBEN.

Von TH. S. SCHTSCHERBAKOW (Laboratorium des Zoolog. Museums der Universität Moskau).

In den Jahren 1897/98 wurde eine interessante Untersuchung von *H. H. Brindley** veröffentlicht zur Frage der Regeneration der Füsse der *Blattidae* in Zusammenhang mit der Erscheinung eines viergliederigen Tarsus bei denselben. Diese Abhandlung beruhte auf einer grossen Menge Materials. Der Autor hat beinahe bewiesen, dass der viergliedrige Tarsus der Schaben ein Regenerationsprodukt ist, und keine "congenital variation" Erscheinung.

Ich nahm mir vor, seine Schlussfolgerungen statistisch zu kontrollieren, da ich 4839 Stück *Stylopyga orientalis* zur Verfügung hatte. Darunter waren erwachsen und geschlechtsreif (22—27 mm. lang) 1768 Exemplare, 402 ♂♂ und 1366 ♀♀; nicht geschlechtsreif waren 250 Stück (von 15—20 mm. Länge); deren Geschlecht nicht festgestellt wurde, da ich die hierzu erforderlichen Sektionen nicht vornahm; ebensolcher Individuen (von 10—15 mm. Länge) gab es 554, und ebenso geschlechtsunreifer, vor kurzem aus dem Kokon gekommener (von 10—5 mm. Länge und kleiner) hatte ich 2267 Stück. *Brindley* hatte nur 3611 Exemplare derselben Art zur Verfügung: 1635 "adult," d. h. geschlechtsreifer, und 1976 "young" (nicht geschlechtsreifer). Somit hatte ich mehr Material in meinen Händen, als *Brindley*, und zwar um 133 erwachsene und 1095 nicht geschlechtsreife Stück. Alle diese Individuen waren von mir im Laufe von etwa 2 Wochen (Ende April 1907 bis Anfang Mai desselben Jahres) in der Stadt Serpuchow (Gouvernement Moskau, Zentralrussland) gefangen worden, in der Küche eines Hauses, in dem die Schaben fast gar nicht verfolgt wurden und reichliche Nahrung fanden in Form von rohen und gekochten Kartoffeln und russischen Roggenbrotes, die in für die Nacht unverschlossenen Tischen und Schränken aufbewahrt wurden. Das Sammeln fand in folgender Weise statt: regelmässig jede Nacht bewaffnete ich mich mit einer entomologischen, flachendigen Pinzette und einem grossen Glasgefäss mit Spiritus und fing die Schaben auf der Diele, an den Wänden, in den Schränken, indem ich jedes Stück vorsichtig mit der Pinzette griff und sofort in den Spiritus

* *Proc. Zoolog. Soc.* London, 1897, pp. 903—916, 1898, p. 924 ff.

warf. Auf diese Art fing ich sehr wenig Schaben, verscheuchte sie vielmehr. Darum wandte ich ferner folgende Methode an: ich umband die Aussenseite niedriger messingener, eiserner Schüsseln und Glasgefässe mit Lappen, um den Schaben den Zutritt zum Innern dieser Gefässe zu erleichtern und legte grosse Stücke Roggenbrot (frisches) in dieselben hinein, nachdem ich die obere Fläche dieser Stücke mit ungereinigtem Vaselin beschmiert hatte, der gehörig mit einer schwachen Lösung Arseniksalz vermengt war. Letzteres wurde dem Vaselin zu dem Zwecke beigemengt, damit die Schaben, nachdem sie vom Brot und Vaselin genossen hatten, nicht im Gefässe herumliefen und ihre Füsse nicht beschädigten, und wenn sie in den Schüsseln von einem Ende zum andern rannten unter den Dutzenden und Hunderten ihrer Gefährten, sich nicht gegenseitig drückten und zu Krüppeln machten. In der Tat fand ich am Morgen in den Gefässen Schaben, die nicht mehr zu schnellem Laufe fähig waren, wohl aber noch lebten und langsam umherkrochen. Der ganze Fang wurde am Morgen in Spiritus geworfen. Diese Fangweise ergab gute Resultate; nur ihr habe ich die grosse Menge behender, junger Schaben zu verdanken. In dem Hause, in dem ich den Fang ausübte, lebte *nur ausschliesslich* die eine Art *Stylopyga orientalis*, davon überzeugte ich mich durch eine Reihe von Besichtigungen und Nachsuchen. Daher bestand mein Material nur aus Repräsentanten dieser Art und unter der ganzen Menge geschlechtsunreifer Individuen, die mir als Material dienten, gab es nicht ein einziges Exemplar *Phyllodromia germanica*. So hatte ich ein absolut reines, reiches Material zur Verfügung. Nach Durchsicht des ganzen Materials an schwarzen Schaben erhielt ich folgende Zahlen:

Geschlechtsreife Individuen.

Im ganzen 1768 Stück. 402 ♂♂, 1366 ♀♀. Fälle mit viergliedrigem Tarsus im ganzen 427. Allerlei Mutilationen 313*.

Nichtgeschlechtsreife Individuen.

(*a*) Länge 15—20 mm.

250 Stück. Fälle mit 4-gliedrigem Tarsus im ganzen 47. Allerlei Mutilationen 18.

(*b*) Länge 10—15 mm.

554 Stück. Fälle mit 4-gliedrigem Tarsus im ganzen 51. Allerlei Mutilationen 19.

(*c*) Länge 10—5 mm. und *kleiner*.

2267 Stück. Fälle mit 4-gliedrigem Tarsus im ganzen 5. Allerlei Mutilationen 0†.

* Unter "Mutilation" verstehe ich allerlei Brüche der Tarsen (Füsse) an verschiedenen Gelenken, Beschädigungen und allerlei Verkrüppelungen an denselben und ihren Teilen.

† Es gab wohl Mutilationen unter den Individuen von dieser Grösse, aber in Rücksicht darauf, dass das Material höchst spröde und brüchig und in starkem Spiritus gelegen hatte, habe ich dieselben nicht mit in Rechnung gezogen, da ich annehme, dass sie durch das Herausholen des Materials aus dem Gefäss entstanden sind.

Im ganzen 4839 Stück. Gesamtzahl der Fälle mit 4-gliedrigem Tarsus 530. Gesamtzahl der Mutilationen 350.

In Prozenten ausgedrückt würden unsere Zahlen wie folgt erscheinen:

Geschlechtsreife Individuen; °/₀ der 4-gliedrigen Tarsus im Verhältnis zur

Gesamtzahl der Individuen:	zur Zahl der ♂♂:	zur Zahl der ♀♀:
24,15	20,69	25,109.

Geschlechtsunreife Individuen; °/₀ der 4-gliedrigen Tarsus für

(*a*) Individuen von 15—20 mm. Länge ——— 18,8

(*b*) „ „ 10—15 „ „ ——— 9,205

(*c*) „ „ 10—5 „ „ und kleiner 0,22.

Für die Gesamtzahl der geschlechtsunreifen Individuen 3,35.

Für die Gesamtzahl der geschlechtsreifen und geschlechtsunreifen Individuen 10,95.

Wenn wir unsere °/₀-Zahlen mit denen von *H. Brindley* vergleichen, sehen wir, dass die °/₀-Zahlen der viergliedrigen Tarsus für geschlechtsreife ♂♂ bei uns wie bei *Brindley* fast gleich sind (bei uns 20,69 °/₀, bei *Brindley* 20,6 °/₀). Der Prozentsatz der 4-gliedrigen Tarsus bei unseren ♀♀ ist höher als bei *Brindley* (bei uns 25,109 °/₀, bei *Brindley* 21,8 °/₀). Was aber die geschlechtsunreifen Individuen anbelangt, so hat *Brindley* nicht den Unterschied nach den Grösseverhältnissen durchgeführt. Wenn wir also die vorletzte Kategorie vergleichen, sehen wir, dass der °/₀-Satz der 4-gliedrigen Tarsus bei allen geschlechtsunreifen Individuen bei uns viel niedriger ist, als bei *Brindley* (bei uns 3,35 °/₀, bei *Brindley* 16,4 °/₀). Der Gesamtprozentsatz der 4-gliedrigen Tarsus für alle geschlechtsreifen und geschlechtsunreifen Individuen ist bei uns ebenfalls bedeutend niedriger (bei uns 10,95 °/₀, bei *Brindley* 18,7 °/₀). Ein so niedriger Prozentsatz an 4-gliedrigen Tarsus für die Gesamtzahl der Individuen überhaupt und ebenso für die geschlechtsunreifen Formen bei mir, lässt sich dadurch erklären, wie ich annehme, dass ich ein 1½ mal grössere Anzahl von geschlechtsunreifen Individuen bearbeitete, als von geschlechtsreifen. Ich hatte an geschlechtsunreifen Individuen um 1095 Stück mehr zur Verfügung, als *Brindley* (d. h. 3071, *Brindley* aber 1976). Man muss berücksichtigen, wie schnell der °/₀-Satz der 4-gliedrigen Tarsus mit dem Sinken der Grössenverhältnisse fällt. Besonders in die Augen fallend ist der Sprung des °/₀-Satzes beim Übergang von den 10–15 mm. langen Individuen zu den 10–5 mm. langen und noch kleineren Stücken. Hätte *H. Brindley* die doppelte Zahl junger Schaben zur Verfügung gehabt, so hätte auch er andere °/₀ Verhältnisse erhalten.

Gehen wir an eine weitere Analyse unserer Daten, um sie mit den Ergebnissen *H. Brindleys* zu vergleichen.

"In the great majority of cases only one of the six legs bore a 4-jointed tarsus, though many individuals possessed the abnormality on more than one leg," schreibt

H. Brindley. Er fand, dass in der Gradation bei der schwarzen Schabe sich folgendes beobachten lässt:

4-gliedrige Tarsus:

an 1 Fuss,	an 2 Füssen,	an 3 Füssen,	an 4 Füssen,	an 5 Füssen,	an 6 Füssen.
588 Fälle,	108 Fälle,	23 Fälle,	10 Fälle,	0 Fälle,	4 Fälle.

Ich habe meinerseits nach meinen Berechnungen folgende Resultate erhalten:

4-gliedrige Tarsus:

bei der Gesamtzahl aller Individuen ("adult" und "young"):

an 1 Fuss,	an 2 Füssen,	an 3 Füssen,	an 4 Füssen,	an 5 Füssen,	an 6 Füssen.
397 Fälle,	67 Fälle,	5 Fälle,	1 Fall,	0 Fälle,	0 Fälle.

Wenn man aber dieselben Daten nach der Körperlänge geordnet durchmustert, so kommt man zu folgendem Resultate:

Geschlechtsreife Individuen:

an 1Fuss,	an 2 Füssen,	an 3 Füssen,	an 4 Füssen,	an 5 Füssen,	an 6 Füssen.
313 Fälle,	58 Fälle,	5 Fälle,	1 Fall,	0 Fälle,	0 Fälle.

Geschlechtsunreife Individuen:

(*a*) Länge 15—20 mm.

an 1 Fuss,	an 2 Füssen,	an 3 Füssen,	an 4 Füssen,	an 5 Füssen,	an 6 Füssen.
37 Fälle,	5 Fälle,	0 Fälle,	0 —,	0 —,	0 —.

(*b*) Länge 10—15 mm.

an 1 Fuss,	an 2 Füssen,	an 3 Füssen,	an 4 Füssen,	an 5 Füssen,	an 6 Füssen.
44 Fälle,	3 Fälle,	0 —,	0 —,	0 —,	0 —.

(*c*) Länge 10—5 mm. und kleiner.

an 1 Fuss,	an 2 Füssen,	an 3 Füssen,	an 4 Füssen,	an 5 Füssen,	an 6 Füssen.
3 Fälle,	1 Fall,	0 —,	0 —,	0 —,	0 —.

Brindley's Zahlen sind viel höher, als unsere (wenn man die Daten seiner Tabelle mit denen der meinigen hinsichtlich der Gesamtzahl aller Individuen vergleicht). Bemerkt muss noch werden, dass mir *eine* der von mir untersuchten Schaben einen 4-gliedrigen Tarsus an vier Füssen zugleich hatte. Mehr als 4 anomale Tarsus bei ein und demselben Individuum habe ich kein Mal gefunden, während der englische Verfasser 4 anomale Tarsus in 10 Fällen hatte und 6 anomale in vier Fällen.

Man muss bedauern, dass *Brindley* die Anzahl anomaler Tarsus, die gleichzeitig bei *einem* Individuum vorkommen, nicht nach Altersgruppen geordnet untersucht hat, indem er letztere durch die Längenmasse des Körpers bezeichnete. Meine Daten weisen sehr lehrreiche und interessante Sprünge in der Zahl der Fälle von anomalen Tarsus bei einem Individuum beim Übergange zur letzten Altersgruppe auf. Nur bei einem von 2267 Individuen von 10—5 mm. Länge und kleiner

wurden anomale Tarsus an zwei Füssen zugleich beobachtet und nur bei 3 Stück, die zu derselben Grössenkategorie gehörten, wurde ein anomaler Tarsus an einem Fusse beobachtet! Alle übrigen Individuen hatten also vollkommen normale Füsse. Wir wollen auch noch hervorheben, dass nicht ein einziges geschlechtsunreifes Individuum mehr als an zwei Füssen anomale Tarsus besass.

Brindley fand, dass bei den von ihm untersuchten schwarzen Schaben folgende Häufigkeit der anomalen Tarsus in der Reihenfolge jedes der drei Beinpaare (in Prozenten ausgedrückt) statt hatte:

	1tes Beinpaar:	2tes Beinpaar:	3tes Beinpaar:
"adult":	26,9 °/₀	22,9 °/₀	50,2 °/₀
"young":	15,7 °/₀	27,7 °/₀	56,4 °/₀
"total":	21,4 °/₀	25,4 °/₀	53,2 °/₀

Nach meiner Berechnung erhielt ich folgende Resultate:

Geschlechtsreife Individuen:

28,33 °/₀	24,12 °/₀	47,54 °/₀

Nichtgeschlechtsreife Individuen:

20,38 °/₀	27,18 °/₀	49,51 °/₀

"Total":

26,79 °/₀	24,71 °/₀	48,47 °/₀

Nichtgeschlechtsreife Individuen (nach Altersgruppen):

(*a*) Länge 15—20 mm.:

5,17 °/₀	7,05 °/₀	9,87 °/₀

(*b*) Länge 15—10 mm.:

4,08 °/₀	6,63 °/₀	15,3 °/₀

(*c*) Länge 10—5 mm. und kleiner:

0,1 °/₀	0 °/₀	0,15 °/₀

Bei den von mir untersuchten geschlechtsreifen Formen war der °/₀-Satz der anomalen Tarsus am 1sten Paar Füsse um 1,43 °/₀ höher, als bei *Brindley*. Am 2ten Beinpaar bei denselben Individuen ist mein Prozentsatz um 1,22 °/₀ höher, am dritten Beinpaar um 2,66 °/₀ *niedriger*, als bei *Brindley*. Was die jungen Stücke anbelangt, so ist mein Prozentsatz für das 1te Beinpaar um 4,68 °/₀ höher, für das 2te um 0,52 °/₀ niedriger, für das 3te ebenfalls um 6,89 °/₀ niedriger. Was aber die Rubrik "Total" anbetrifft, so steht die Sache folgendermassen: für das erste Beinpaar sind meine Zahlen um 5,39 °/₀ höher, als die von *Brindley*, für das 2te um 0,69 °/₀ niedriger und für das 3te auch um 4,73 °/₀ geringer. Die Daten für die Nichtgeschlechtsreifen nach Altersgruppen lassen sich nicht vergleichen, da in *Brindley's* Tabellen diese Kategorie fehlt.

Sehr interessant ist der Umstand, dass sowohl in meiner wie in *Brindley's* Tabelle der °/₀-Satz der 4-gliedrigen Tarsus für das 2te Beinpaar bei den "adult"

niedriger ist als für das 1ste Beinpaar. Bei den als "young" bezeichneten Individuen (nichtgeschlechtsreif) ist derselbe °/₀-Satz höher. In der Kategorie "Total" ist derselbe bei *Brindley* höher, bei mir geringer. Wenn man aber die nichtgeschlechtsreifen Individuen nach Altersstufen untersucht, so wächst derselbe, während er in der Gruppe 10—5 mm. und kleiner = 0 ist, in der folgenden Gruppe plötzlich, indem er viel höher sich stellt, als der entsprechende °/₀-Satz für das 1ste Beinpaar. Warum fällt er in der Kategorie "adult"?

"The long third pair of legs seem to suffer more from their exposed condition, as compared with the less extended anterior pairs," sagt *Brindley*. Warum aber hat das zweite Paar Beine einen geringeren Prozentsatz anomaler Tarsus? Mir scheint deshalb, weil es zwischen dem ersten und dritten Paar befindlich mehr vor Zufällen von hinten geschützt ist, als das dritte Paar, und von vorne mehr als das erste. Vor allem leiden durch allerlei Verletzungen die beiden äussersten Paare— das erste und dritte, und dann erst das zweite, das sich zwischen ihnen befindet, wie zwischen zwei Schilden. Diese Erklärung passt aber nur für die Kategorie "adult," die geschlechtsreifen Individuen, und lässt sich durchaus nicht auf die "young" und nichtgeschlechtsreifen Tiere anwenden. Bei letzteren wächst der Prozentsatz anomaler Tarsus mit dem Übergange vom ersten Paar zum zweiten und von diesem zum dritten.

Gehen wir jetzt zur weiteren Analyse unserer Daten im Vergleich zu denen in *Brindley's* Arbeit über.

"The abnormal tarsi occurred indifferently on the right and left sides—thus, in 1329 cases in *S. orientalis* 661 were on the right and 668 on the left side," schreibt *Brindley*. Meine Zahlen ergeben dasselbe:

Geschlechtsreife Individuen:

ein viergliederiger Tarsus fand sich

auf der linken Seite:	auf der rechten Seite:
in 212 Fällen	in 215 Fällen

Geschlechtsunreife Individuen:

(*a*) Länge 15—20 mm.:	
in 24 „	in 23 „
(*b*) Länge 10—15 mm.:	
„ 24 „	„ 27 „
(*c*) Länge 10—5 mm. und kleiner:	
„ 3 „	„ 2 „
Gesamtzahl für die Geschlechtsunreifen:	
„ 51 „	„ 52 „
Gesamtzahl für beide Kategorien:	
„ 263 „	„ 267 „

Eine solche Unterschiedslosigkeit für das Verhalten der rechten und linken Seite ist ohne jede Erklärung klar begreiflich.

H. Brindley stellte auf experimentellem Wege fest, dass nach entsprechenden Verletzungen der Tarsen, die schwarzen Schaben nach den Häutungen viergliedrige Tarsus erhielten. Er sagt in seiner Arbeit nichts darüber, ob er irgend welche Verwundungen oder Trauma an dem von ihm untersuchten und konservierten Material vorfand, und wenn er solche vorgefunden hat, weshalb hat er diese Erscheinungen nicht untersucht, weshalb hat er dieselben, so zu sagen, als quantité négligeable angesehen?

Als ich mein konserviertes Material durchmusterte, fand ich am selben nicht wenig verschiedenartige Traumata. In meinen Notizen vermerkte ich bloss die *Traumata ante captivationem.* Die letzteren besitzen charakteristische Merkmale, die es gestatten, sie unter den Fällen von Traumata post mortem zu erkennen: das ist eine schwarzbraune Narbe an der Stelle der Verwundung, eine gewisse Runzelung des Chitins um dieselbe; ähnliche Merkmale beobachtete ich auch an lebenden Tarakanen (Schaben), die ich in Käfigen hielt, nachdem ich ihnen vorher die Füsse an verschiedenen Gelenkstellen beschnitten hatte. *H. Brindley* selbst sagt, dass bei einer Schabe, die in spirito gelegen habe, eine leichte Brüchigkeit der Beine in der Gegend des tarso-tibialen Gelenkes zu bemerken ist, während Femur und Tibia nur gewaltsam getrennt werden können. Die Verwundungen ante captivationem sind scharf unterschiedbar von den Traumata post captivationem et post mortem: eine Narbe mit scharfem Dunkelwerden des Chitins in letzterem Falle habe ich nie beobachtet, während dieses für Verwundungen der ersten Kategorie charakteristisch ist. Es ist natürlich möglich, dass in meinen Zahlen sich Ungenauigkeiten finden: bei dem eiligen Fange von Schaben mit der Pinzette in der Hand konnte ich ihnen Verletzungen zufügen—und oft entkamen mir solche Schaben und gerieten dann vielleicht nach einigen Tagen unter mein Material, indem sie in die Fanggefässe krochen. Andererseits konnte ich mit der Pinzette in den Spiritus Schaben werfen, und ihnen hierbei die Füsse verletzen und diese konnten keine Narbe an der Verwundungsstelle bilden und gerieten auf diese Weise in die Kategorie der Verwundungen post captivationem et mortem, welche ich nicht registrierte. Wenn man aber in Betracht zieht, dass diese beiden Reihen von Verletzungen beim Fange einander entgegengesetzt sind in Hinsicht der Registration der Traumata, und wenn man im Auge behält, dass ich mit der entomologischen Pinzette, wie oben gesagt, verhältnismässig wenig Schaben gefangen habe, so glaube ich, dass in meinen Zahlen nur eine geringe Ungenauigkeit vorwalten kann.

Und somit wollen wir an die Betrachtung der Traumata gehen. Vor allem will ich mitteilen, welcher Art Verletzungen ich beobachtete und registrierte. Zerreissungen im Gebiet der tarso-tibialen und Femoro-trochanter-Gelenke (sehr selten im Gebiet der tibio-femoralen Einlenkungen), Brüche der einzelnen Tarsenglieder, Abbrechen der Krallen sowohl am normalen fünfgliedrigen, wie auch am anomalen viergliedrigen Tarsus—das sind die bei meinem Material häufigsten

Traumafälle. Alle diese Traumata wurden an geschlechtsreifen Individuen gefunden; bei den nichtgeschlechtsreifen wurden dieselben Verletzungen bemerkt, ausgenommen die tibio-femoralen Zerreissungen, die niemals bei ihnen beobachtet wurden. Ausserdem wurden einige andere Verletzungen registriert: Zerreissungen in der Trochantero-coxal-Einlenkung (ein Fall bei einem Imago ♂), Abbrechen des *ganzen* Fusses (1 Fall bei einem Imago ♂), Abbruch des ganzen Tarsus und Verkrümmung des Tibiaendes (1 Fall bei einem ♂-Imago), Abbruch, der fast mitten über das erste (von der Tibia aus gerechnet) Tarsusglied ging, so dass die Hälfte des Gliedes erhalten blieb (1 Fall bei einem Individuum bei der Kategorie 15—20 mm. langer Larven), Abbruch des ganzen Tarsus und Verkrüppelung der Tibia (1 Fall bei einem Individuum aus der Kategorie 10—15 mm. langer Larven).

Gehen wir an die Durchsicht der ziffernmässigen Daten hinsichtlich der Verwundungen und beginnen wir mit den geschlechtsreifen Individuen. In dieser Kategorie waren alle abmassgeführten Verletzungen bei 231 Individuen beobachtet worden, ♂♂ 90 und ♀♀ 141, oder in Prozenten ausgedrückt bei 13,06 °/₀ beider Geschlechter, bei 22,43 °/₀ aller Männchen u. bei 10,32 °/₀ aller Weibchen. Die hierher gehörigen Zahlen sind folgende:

Traumata bei Geschlechtsreifen:

Tarso-tibiale Traumata:

im ganzen 124 Fälle von Trauma:

am 1sten	rechten Fuss	8 Fälle	}	17 Fälle—in °/₀ °/₀	= 13,7 °/₀.
„ „	linken „	9 „	}		
„ 2ten	rechten „	20 „	}	37 Fälle— „ „	= 29,83 °/₀.
„ „	linken „	17 „	}		
„ 3ten	rechten „	35 „	}	70 „ —„ „	= 56,45 °/₀.
„ „	linken „	35 „	}		

Femoro-trochanter-Traumata:

im ganzen 109 Fälle von Trauma:

am 1sten	rechten Fuss	10 Fälle	}	23 Fälle, in °/₀ °/₀	= 21,1 °/₀.
„ „	linken „	13 „	}		
„ 2ten	rechten „	11 „	}	25 „ „ „	= 23,02 °/₀.
„ „	linken „	14 „	}		
„ 3ten	rechten „	27 „	}	61 „ „ „	= 55,96 °/₀.
„ „	linken „	34 „	}		

Abbruch der Krallen (fünfgliedriger Tarsus), im ganzen 22 Fälle:

am 1sten	rechten Fuss	3 Fälle	}	5 Fälle, in °/₀ °/₀	= 22,72 °/₀.
„ „	linken „	2 „	}		
„ 2ten	rechten „	5 „	}	9 „ „ „	= 40,90 °/₀.
„ „	linken „	4 „	}		
„ 3ten	rechten „	6 „	}	8 „ „ „	= 36,36 °/₀.
„	linken „	2 „	}		

Abbruch der Krallen (viergliedriger Tarsus):

im ganzen 3 Fälle:

am 1sten	rechten	Fuss	1	Fall	das prozentuale Verhältnis wurde nicht berechnet.
„ „	linken	„	0	Fälle	
„ 2ten	rechten	„	0	„	
„ „	linken	„	0	„	
„ 3ten	rechten	„	2	„	
„ „	linken	„	0	„	

Abbruch der Tarsusglieder:

im ganzen 43 Fälle:

4	Glieder	abgebrochen :	6	Fälle,	in °/₀ °/₀	=	13,95 °/₀
3	„	„ :	4	„	„ „	=	9,3 °/₀
2	„	„ :	9	„	„ „	=	20,93 °/₀
1	Glied	„ :	24	„	„ „	=	55,8 °/₀.

am 1sten	rechten	Fuss	8	Fälle	von Abbruch	12, in °/₀ °/₀ = 27,9 °/₀
„ „	linken	„	4	„	„ „	
„ 2ten	rechten	„	4	„	„ „	9, „ „ = 20,93 °/₀
„ „	linken	„	5	„	„ „	
„ 3ten	rechten	„	11	„	„ „	22, „ „ = 51,16 °/₀
„ „	linken	„	11	„	„ „	

Tibio-femorale Traumata:

im ganzen 4 Fälle:

am 1sten	rechten	Fuss	0	Fälle	0	das prozentuale Verhältnis wurde nicht berechnet.
„ „	linken	„	0	„		
„ 2ten	rechten	„	0	„	3	
„ „	linken	„	3	„		
„ 3ten	rechten	„	1	Fall	1	
„ „	linken	„	0	„		

Trochantero-coxale Traumata:

im ganzen 1 Fall:

am 3ten rechten Fuss:

Abbruch des ganzen Fusses:

im ganzen 1 Fall:

am 1sten rechten Fuss.

Abbruch des Tarsus und Vorbiegung der Tibia:

im ganzen 1 Fall:

am 3ten linken Fuss.

Wenden wir uns den Traumata bei geschlechtsunreifen Individuen zu und sehen wir uns zuerst die Traumata überhaupt für alle geschlechtsunreifen Formen an.

Traumata bei der Gesamtheit der Geschlechtsunreifen:

Tarso-tibiale Traumata:

im ganzen 13 Fälle:

am 1sten	rechten	Fuss	1	Fall	1, in °/₀ °/₀ =	7,68 °/₀
„ „	linken	„	0	Fälle		
„ 2ten	rechten	„	1	Fall	4, „ „ =	30,72 °/₀
„ „	linken	„	3	Fälle		
„ 3ten	rechten	„	5	„	8, „ „ =	61,44 °/₀.
„ „	linken	„	3	„		

Femoro-trochanter-Traumata:

im ganzen 11 Fälle:

am 1sten	rechten	Fuss	0	Fälle	1, in °/₀ °/₀ =	9,09 °/₀
„ „	linken	„	1	Fall		
„ 2ten	rechten	„	1	„	3, „ „ =	27,27 °/₀
„ „	linken	„	2	Fälle		
„ 3ten	rechten	„	3	„	7, „ „ =	63,63 °/₀.
„ „	linken	„	4	„		

Abbruch von Krallen (fünfgliedriger Tarsus):

im ganzen 6 Fälle:

am 1sten	rechten	Fuss	1	Fall	2, in °/₀ °/₀ =	33,2 °/₀
„ „	linken	„	1	„		
„ 2ten	rechten	„	2	Fälle	3, „ „ =	49,8 °/₀
„ „	linken	„	1	Fall		
„ 3ten	rechten	„	1	„	1, „ „ =	16,6 °/₀.
„ „	linken	„	0	Fälle		

Abbruch von Tarsusgliedern:

im ganzen 5 Fälle:

	Abgebrochen	4	Glieder,	0	Fälle, in °/₀ °/₀ =	0 °/₀
	„	3	„	0	„ „ „ =	0 °/₀
	„	2	„	1	Fall, „ „ =	20 °/₀
	„	1	Glied	4	Fälle, „ „ =	80 °/₀.
am 1sten	rechten	Fuss	1	Fall	2, in °/₀ °/₀ =	40 °/₀
„ „	linken	„	1	„		
„ 2ten	rechten	„	0	Fälle	1, „ „ =	20 °/₀
„ „	linken	„	1	Fall		
„ 3ten	rechten	„	2	Fälle	2, „ „ =	40 °/₀.
„ „	linken	„	0	„		

Wenden wir uns nun der Traumata bei denselben geschlechtsunreifen Individuen zu, indem wir sie nach den schon oben angegebenen Altersabstufungen ordnen:

Geschlechtsunreife Individuen:

(*a*) Länge 15—20 mm.

Tarso-tibial-Traumata:

im ganzen 6 Fälle:

am 1sten	rechten	Fuss	1	Fall	} 1, in °/₀ °/₀ = 16,6 °/₀
„ „	linken	„	0	Fälle	
„ 2ten	rechten	„	0	„	} 1, „ „ = 16,6 °/₀
„ „	linken	„	1	Fall	
„ 3ten	rechten	„	3	Fälle	} 4, „ „ = 66,6 °/₀.
„ „	linken	„	1	Fall	

Femoro-trochanter-Traumata:

im ganzen 5 Fälle:

am 1sten	rechten	Fuss	0	Fälle	} 1, in °/₀ °/₀ = 20 °/₀
„ „	linken	„	1	Fall	
„ 2ten	rechten	„	1	„	} 1, „ „ = 20 °/₀
„ „	linken	„	0	Fälle	
„ 3ten	rechten	„	2	„	} 3, „ „ = 60 °/₀.
„ „	linken	„	1	Fall	

Abbruch der Krallen (fünfgliedriger Tarsus):

im ganzen 3 Fälle:

am 1sten	rechten	Fuss	1	Fall	} 1	in °/₀ °/₀ = 33,3 °/₀.
„ „	linken	„	0	Fälle		
„ 2ten	rechten	„	1	Fall	} 1	
„ „	linken	„	0	Fälle		
„ 3ten	rechten	„	1	Fall	} 1	
„ „	linken	„	0	Fälle		

Abbruch von Tarsengliedern:

im ganzen 3 Fälle:

4	Glieder	abgebrochen	:	0	Fälle,	in °/₀ °/₀ = 0 °/₀
3	„	„	:	0	„ „	= 0 °/₀
2	„	„	:	1	Fall „	= 33,3 °/₀
1	Glied	„	:	2	Fälle „	= 66,6 °/₀.

am 1sten	rechten	Fuss	1	Fall	} 1, in °/₀ °/₀ = 33,3 °/₀
„ „	linken	„	0	Fälle	
„ 2ten	rechten	„	0	„	} 0, „ „ = 0 °/₀
„ „	linken	„	0	„	
„ 3ten	rechten	„	2	„	} 2, „ „ = 66,6 °/₀.
„ „	linken	„	0	„	

Abbruch des ersten Tarsengliedes in der Mitte seiner Länge:
ein Fall:
am 3ten linken Fuss.

(*b*) Länge 10—15 mm.

Tarso-tibial-Traumata:
im ganzen 7 Fälle:

am 1sten	rechten	Fuss	0	Fälle	0, in °/₀ °/₀ = 0 °/₀
„ „	linken	„	0	„	
„ 2ten	rechten	„	1	Fall	3, „ „ = 42,84 °/₀
„ „	linken	„	2	Falle	
„ 3ten	rechten	„	2	„	4, „ „ = 57,12 °/₀.
„ „	linken	„	2	„	

Femoro-trochanter-Traumata:
im ganzen 6 Fälle:

am 1sten	rechten	Fuss	0	Fälle	0, in °/₀ °/₀ = 0 °/₀
„ „	linken	„	0	„	
„ 2ten	rechten	„	0	„	2, „ „ = 33,2 °/₀
„ „	linken	„	2	„	
„ 3ten	rechten	„	1	Fall	4, „ „ = 66,4 °/₀.
„ „	linken	„	3	Fälle	

Abbruch der Krallen (5-gliedriger Tarsus):
im ganzen 3 Fälle:

am 1sten	rechten	Fuss	0	Fälle	1, in °/₀ °/₀ = 33,3 °/₀
„ „	linken	„	1	Fall	
„ 2ten	rechten	„	1	„	2, „ „ = 66,6 °/₀
„ „	linken	„	1	„	
„ 3ten	rechten	„	0	Fälle	0, „ „ = 0 °/₀.
„ „	linken	„	0	„	

Abbruch von Tarsengliedern:
im ganzen 2 Fälle:

4	Glieder	abgebrochen	: 0	Fälle, in	°/₀ °/₀ = 0 °/₀
3	„	„	: 0	„ „	„ = 0 °/₀
2	„	„	: 0	„ „	„ = 0 °/₀
1	Glied	„	: 2	„ „	„ = 100 °/₀.

am 1sten	rechten	Fuss	0	Fälle	1, in °/₀ °/₀ = 50 °/₀
„ „	linken	„	1	Fall	
„ 2ten	rechten	„	0	Fälle	1, „ „ = 50 °/₀
„ „	linken	„	1	Fall	
„ 3ten	rechten	„	0	Fälle	0, „ „ = 0 °/₀.
„ „	linken	„	0	„	

Abbruch des ganzen Tarsus und verkrüppelte Tibia:

im ganzen 1 Fall:

am 2ten rechten Fuss.

(*c*) Länge 10—5 mm. und kleiner:

kein Fall.

(Verkrüppelungen und Traumata wurden nicht registriert, weil sie in Menge als Erscheinungen post captivationem et mortem auftraten.)

Wir sahen schon oben, dass der Prozentsatz der anomalen (viergliedrigen) Tarsus mit dem Übergange von jedem nach vorne gelegenen Beinpaare zum folgenden steigt und dass besonders dieses Ansteigen am dritten Fusspaar bedeutend erscheint. Wenn wir nun die Traumata nehmen, so sehen wir, dass dieselbe Gesetzmässigkeit auch bei folgenden Traumata vorherrscht:

(1) bei den tarso-tibialen Traumata (bei geschlechtsreifen Individuen, bei den nichtgeschlechtsreifen überhaupt, in der Kategorie derselben von 15—20 mm. und von 10—15 mm Länge);

(2) bei den Femoro-trochanter-Traumata (bei geschlechtsreifen Individuen, bei den nichtgeschlechtsreifen überhaupt, bei denen der Kategorien 15—20 mm., sowie 10—15 mm. Länge).

(3) Abbruch von Tarsengliedern (bei geschlechtsreifen Individuen, nichtgeschlechtsreifen überhaupt und denen der Kategorien 15—20 mm. und 10—15 mm. Länge). Was aber den Abbruch von Krallen anbelangt, so ist diese Art Trauma, während sie in Hinsicht auf Gesetzmässigkeit der oben angeführten analog ist bei den Individuen die die Geschlechtsreife erlangten, bei den nichtgeschlechtsreifen Tieren keiner greifbaren Gesetzmässigkeit unterworfen (oder eher ohne alle Gesetzmässigkeit). Alle übrigen Fälle von Traumata (tibio-femorale u. s. w.) unterliegen gar keiner Gesetzmässigkeit.

Wenden wir nun unsere Aufmerksamkeit den tarso-tibialen und femoro-trochanter-Traumata zu. *H. Brindley* weist bei Mitteilung über seine Versuche über die Regeneration des Tarsus bei der schwarzen Schabe in die Tabelle E seiner Arbeit darauf hin, was für Verletzungen und an welchen Stellen der Beine er sie den von ihm zu Experimenten benutzten Schaben beibrachte.

Unten gebe ich diese Tabelle wieder und füge derselben rechts ein Rubrik bei, in welcher ich die Prozentsätze der regenerierten 4-gliedrigen Tarsus ausrechnete.

Aus dieser Tabelle ersehen wir, dass ausser der oberen Rubrik ("t_2 torn away from t_1"), die tarso-tibialen und Femoro-trochanter-Traumata den grössten Prozentsatz regenerierter viergliedriger Tarsen lieferten. Hierbei wollen wir hervorheben, dass die Entfernung der bezeichneten Glieder nicht mit Instrumenten (z. B. "scissors"), sondern so geschah, wie es unter natürlichen Verhältnissen des Schabenlebens vor sich geht—durch einfaches Abreissen eines Gliedes von dem andern. Aber das ist noch nicht genügend, die Form der Verletzung selbst, das Abreissen eines Gliedes vom andern *an der Stelle der Einlenkung*, entspricht

*H. Brindley's Tabelle E**.

Nature of Mutilation	Leg Mutilated	Number of Mutilations	Number of Reproductions Observed	°/°
t_2 torn away from t_1 ...	3*R*	300	141	47 °/°
t_1 divided with scissors ...	2*L*	21	3	
	3*L*	109	16	14,61 °/°
	Totals	130	19	
Tarsus torn away from tibia ...	2*R*	300	144	
	3*R*	89	45	48,58 °/°
	Totals	389	189	
Tibia divided with scissors ...	3*R*	14	2	
	3*L*	300	122	39,42 °/°
	Totals	314	124	
Femur torn away from trochanter	1*L*	300	137	
	2*R*	17	4	
	3*L*	23	11	44,7 °/°
	Totals	340	152	
	Totals	1473	625	—

der Form von Traumata, die a priori einzig und allein im gewöhnlichen Leben des Insekts vorkommen kann, und die wir schon in unseren oben angeführten Tabellen von Traumata beobachteten. Traumata, die sich *nicht an den Einlenkungsstellen* finden, erscheinen für das gewöhnliche Leben der Schabe als Ausnahme und dabei, wie wir in den Tabellen sahen, als sehr seltene.

Hieraus folgt ganz direkt, dass die von uns in unseren Tabellen aufgeführten Traumata von gesetzmässigem Charakter (der gleich ist mit dem konsequenten Anwachsen des °/° am viergliedrigen Tarsus an jedem folgenden und besonders dem dritten Beinpaar) keine zufälligen sind, sondern notwendigerweise der Regeneration des viergliedrigen Tarsus vorausgehen, wobei das Maximum an Traumata gerade das Paar Beine trifft (das 3te), das auch das Maximum anomaler Tarsus aufzuweisen hat. Der zweite Folgeschluss ist der, dass das Maximum an Verletzungen auf die tarso-tibialen und Femoro-trochanter-Einlenkungen, sowie den Abbruch von Tarsengliedern fällt. Die oben von uns an unserem Material untersuchten drei gesetzmässigen Arten von Traumata gehören gerade in die Reihe derjenigen die in *Brindley's* Versuchen das Maximum an regenerierten anomalen Tarsus ergaben. Es erscheint also der Schluss sehr wahrscheinlich und

* In dieser Tabelle sind folgende Bezeichnungen (nach *Brindley*): R und L = "right" und "left" = rechts u. links; 1, 2 und 3 bezeichnet die Beinpaare der Folge nach; t_1 und t_2 u. s. w. die Tarsenglieder, vom proximalen Gliede aus gerechnet.

der Wirklichkeit sehr nahekommend, dass der viergliedrige Tarsus, den wir bei der schwarzen Schabe beobachten können, als ein Produkt der Regeneration nach Verletzungen der tibio-tarsalen oder Femoro-trochanter-Einlenkungen erscheint, oder des Abbrechens von Tarsusgliedern.

Es ist wahrscheinlich, dass eine jede Verwundung des Schabenfusses (die nicht weiter reicht, als bis zur Femoro-trochanter-Einlenkung) als Choc erscheint, der eine anomale Regeneration der Tarsus hervorruft, aber nicht jede Art von Verwundung kommt im natürlichen Leben der Schabe vor. Die Neigung einiger weniger Einlenkungsstellen zu Traumabildungen im gewöhnlichen Leben der schwarzen Schabe steht, so zu sagen, wahrscheinlich in Abhängigkeit sowohl vom anatomischen Bau dieser Gelenke, im Vergleich zu anderen, als auch von der Art des Gehens und Laufens bei den Schaben. *Brindley* bemerkte schon, dass bei der schwarzen Schabe, wenn sie in Spiritus gelegen hatte, sich eine leichte Brüchigkeit der Tarso-tibial-Gelenke zeigt, während der Femur von der Tibia sich nur bei einiger Gewaltanwendung trennen lässt. Es wäre sehr interessant den Widerstand zu untersuchen, den die verschiedenen Gelenke der Füsse der schwarzen Schabe dem Abgerissenwerden entgegensetzen.

Wenden wir uns wieder unseren Traumatabellen zu. Wenn wir zusehen, wie der Prozentsatz der obenbeschriebenen drei gesetzmässigen Trauma-Arten wächst mit dem Alter der Individuen, so bemerken wir, dass der Prozentsatz dieser Verletzungen bei den nichtgeschlechtsreifen Individuen nicht kleiner ist, als bei den geschlechtsreifen, d. h. dass die Zahl der Traumata mit dem Alter nicht zunimmt (wie man aus dem wenig zahlreichen Material an nichtgeschlechtsreifen Tieren schliessen könnte). Die Traumata stehen also nach den Altersgruppen in anderem Verhältnis zum Prinzip des Anwachsens des Prozentsatzes der Anomalien in Abhängigkeit vom Alter, als der anomale viergliedrige Tarsus. Hierin besteht der Grundunterschied der Traumata vom anomalen Tarsus. Wenn wir uns aber wenden dem Unterschiede der Traumata in Abhängigkeit vom Geschlechte zu, so sehen wir, dass der Prozentsatz an solchen bei den ♂♂ höher ist, als bei den ♀♀, während in Hinsicht des anomalen Tarsus die Sache umgekehrt liegt. Zeigt nicht das eine oder andere Geschlecht, so zu sagen, eine Neigung zu der einen oder andern Traumaform? Für diesen Fall habe ich folgende Zahlung zur Verfügung:

Tarso-tibial-Traumata:

wurden beobachtet bei 58 ♀♀ und 48 ♂♂.

Femoro-trochanter-Traumata:

wurden gefunden bei 62 ♀♀ und 37 ♂♂.

Abbruch der Tarsusglieder:

fand sich bei 21 ♀♀ und 17 ♂♂.

Abbruch der Klauen (am fünfgliedrigen Tarsus):

fand sich bei 14 ♀♀ und 7 ♂♂.

Die Zahlen schwanken in solchen Grenzen, dass man von dem Zusammenhange eines oder des andern Geschlechts mit einer bestimmten Traumaform nicht sprechen kann. Wahrscheinlich unterliegen beide Geschlechter allen Arten von Verletzungen.

Man muss auch noch darauf hinweisen, dass die verschiedenen Arten von Traumata an ein und demselben Individuum gefunden werden, zuweilen kombiniert mit der Anwesenheit der anomalen viergliedrigen Tarsus. Es giebt folgende Trauma-Kombinationen:

Tibio-tarsales und Femoro-trochanter-Trauma;

bei verschiedenen Geschlechtern an verschiedenen Fusspaaren und auf verschiedenen Seiten:

Tibio-tarsales Trauma mit Abbruch von Tarsus-Gliedern (am normalen Tarsus):

bei beiden Geschlechtern an verschiedenen Fusspaaren und auf verschiedenen Seiten;

Femoro-trochanter-Trauma mit Abbruch der Tarsenglieder (am normalen Tarsus):

ebenso;

Tibio-tarsales Trauma mit viergliedrigen Tarsus:

ebenso;

Abbruch der Tarsenglieder (am normalen Tarsus) mit viergliedrigen Tarsus:

ebenso.

Es kommen Traumata einer Art zu gleicher Zeit an mehreren Füssen des Individuums vor (z. B. Femoro-trochanter-Traumata auf der rechten Seite am 2ten und 3ten Paar). Derartiger oben angeführten Kombinationen von verschiedenen Traumaformen mit viergliedrigen Tarsus an einem Individuum an den Füssen verschiedener Paare und Seiten (bei beiden Geschlechtern) zählte ich 39 Fälle bei ♀♀ und 31 Fälle bei ♂♂. Was aber die nicht geschlechtsreifen Individuen angeht, so zählte ich in der Kategorie 15—20 mm. Länge 2 Fälle der oben erwähnten Kombinationen, in der Kategorie 10—15 mm. Länge—im ganzen nur einen Fall.

Wir wollen auch nicht vergessen, dass wir am anomalen viergliedrigen Tarsus ebenfalls Traumata vorfanden: Abbruch von Klauen.

Nach der statistischen Aufstellung von *H. Brindley* und dem vorliegenden Versuche kann man annehmen, wie ich glaube, dass der anomale viergliedrige Tarsus bei *Stylopyga orientalis* (wie bei allen Schaben) als Produkt der Regeneration des normalen fünfgliedrigen Tarsus auftritt, nachdem der Fuss eine Verletzung erlitten, hauptsächlich am Tibio-tarsal- oder Femoro-trochanter-Gelenk, oder nach Abbruch der Tarsenglieder.

Die Frage von den inneren Ursachen eines solchen Verlaufes der Regeneration, wie er bei den *Blattidae* vorkommt, kann ich hier natürlich nicht entscheiden. Das ist schon die Aufgabe des Histologen. Aber ich kann nicht umhin, die Aufmerksamkeit auf die drei oben untersuchten gesetzmässigen Arten von Trauma zu lenken, die am häufigsten im gewöhnlichen Leben der Schabe getroffen werden und als Regenerationsfaktoren dieser vorausgehen; sie verdienen ernste Beachtung auch von Seite des Histologen und um so mehr, als die Frage von den Verletzungen, ihrer Form, Struktur und ihrer Ziffernmässigkeit bis zu dieser Arbeit, soweit mir bekannt, in der Literatur noch nicht angeregt wurde, ausser unbedeutenden Daten, die in Artikeln über Regeneration von Newport und Graber zerstreut sind.

Serpuchow, Januar 1908.

MISCELLANEA.

I. Note on Inheritance of Brachydactyly.

In an addendum to a memoir on "Split Hand and Split Foot Deformities etc." published in *Biometrika*, Vol. VI, Pt. I, 1908, p. 117, the writer, referring to a statement by Punnett to the effect that no member of a brachydactylous family who is free from the defect can transmit it to his or her offspring, stated that this conclusion is disproved by the family recorded by Hasselwander (*Zeitschr. f. Morph. u. Anthrop.* Bd. 6, 1903, S. 510—526), in which such transmission actually occurred. A misprint in the original diagram of the family tree was at the time overlooked, and it appears from a personal communication which the writer has received from Dr Hasselwander, that transmission of the nature stated did not occur.

The remaining two families bearing on the matter under consideration, and quoted in a footnote to the original addendum, may be given in fuller detail. Ammon writes in *Die angebor. chir. Krankh. d. Mensch. u.s.w.* Berlin, 1842, S. 96, as follows:—"Merkwürdig ist in dieser Hinsicht ein von Keltie beobachteter Fall, wo bei den Gliedern einer Familie schon seit zehn Generationen nur der Daumen vollständig gebildet gewesen war, während an den übrigen Fingern entweder beide Gelenke, oder wenigstens das Nagelglied fehlte. Eigenthümlich war dabei, dass sich diese Missbildung nur in den weiblichen Gliedern der Familie fortpflanzte." *

Joachimsthal in *Virchow's Archiv*, Bd. 151, 1898, Folge XV. Bd. 1, S. 430, writes:—"Die 27-jährige, bis auf die zu schildernden Anomalien an beiden Händen normale, 160 cm grosse Patientin weiss über Verbildungen in der Ascendenz nichts zu berichten. Ein 29- und eine 22-jährige Schwester haben, wie sie selbst—wenn auch weniger ausgesprochen—verkürzte Zeige- und Mittelfinger. Der einzige Bruder ist selbst normal gestaltet, besitzt jedoch eine 1-jährige Tochter mit den gleichen Fingerverbildungen, ebenso wie dies bei einem frühzeitig verstorbenen Knaben der älteren Schwester der Fall war. Unsere Patientin selbst ist Mutter eines jetzt 4-jährigen, normalen Knaben. Von den verbildeten Familienmitgliedern habe ich nur die 22-jährige Schwester zu untersuchen vermocht, u.s.w."

In the original addendum the Hasselwander family constituted the most conclusive evidence for the transmission of brachydactylia through a normal individual, and this portion of the evidence must be withdrawn without qualification.

In conclusion, gratitude must be expressed to Mr Punnett for his courtesy in allowing the writer the opportunity of personally correcting the error which has occurred.

July 2, 1908.

THOMAS LEWIS.

II. Note on Inheritance in Man.

The importance of certain considerations being borne in mind with regard to pedigree work is well illustrated by Dr Lewis' note. On looking at Hasselwander's pedigree I personally should consider Dr Lewis' statement correct, not because of the misprint which might attribute some of the children of Fanny to Victoria, a normal individual (for the numbering of the offspring shows that there was a misprint of some sort), but because the writer states directly that the deformed Josepha K. was the child of normal parents.

* The original report of the Keltie family has since been found (*Edin. Med. and Surg. Journ.* 1808, Vol. IV. p. 252). The condition was in all probability the same as that in the Farabee family. The women who transmitted the defect were apparently also malformed, though from the text it is somewhat uncertain.

Now it is at this point that a very important consideration comes in. The true Mendelian needs the theory of mutations to supplement his position, and other workers, among whom, I think, I may include Dr Lewis, would say that the deformity started in a sport. Now an experience covering many hundreds of human pedigrees leads me to the conclusion, that the appearance of deformity in the offspring of normal parents with nothing further known of the earlier ancestry is too often only another way of stating that we have not been able to trace fully the ancestral and their collateral lines. In very many cases when I can go back through a normal parentage, I find directly or collaterally the supposed mutation or sport recurring, and we have either to assert (i) that there exists a general tendency to sporting in the stock, or (ii) that the deformity is latent and can be carried through normal individuals. It is needless to say that (ii) appears to me a more scientific assumption. To stop short at a normal pair with the statement 'sport' or 'mutation' is logically incomplete, if we wish to demonstrate that the deformity is handed down only through deformed individuals. We must show for a generation or two in the direct and collateral lines an entire absence of the abnormality.

It is a very general experience that these abnormal cases belong to the lower classes of the population, and that in going back in the pedigree we are invariably checked at but a few generations by ignorance as to blood-relationships. Under such circumstances we must either wind up with an abnormal individual of unknown parentage or with normal individuals as in Dr Hasselwander's or Dr Lewis' cases. My first consideration is that we have not the evidence necessary to speak of the latter as determining a 'sport.'

My second urgent consideration is this: Is not the time ripe for the collection and publication of pedigrees bearing upon normal and abnormal characters in man? There is an immense amount of published material scattered through a wide journalistic area. There is a growing tendency for medical men to record more and more completely family histories*. A collection of published and unpublished material would be of first class value to students of heredity. The primary conditions for such a collection are: (*a*) that it shall contain the material only; no discussion of hereditary theories shall form part of its plan,—this ought to allow of all schools contributing; (*b*) that there shall be no selection of special pedigrees for publication, except on the score of their completeness and the peculiar interest of their characteristics; (*c*) that each contributor should be wholly responsible for the accuracy of his facts and for the genealogies which should be published under his own name. The duty of the Editor should only be to standardise the material received. With a view to providing a collection of this kind, the Galton Laboratory of National Eugenics proposes to issue in parts a *Treasury of Human Inheritance*, each part will contain 20 to 50 pedigrees arranged on 6 to 10 lithographed plates. The individual plates will be devoted to a special characteristic or abnormality. Each pedigree will be accompanied by a brief account of the family and its members, and when needful by an illustration of the characteristic. The *Treasury* will cover published and unpublished material, and there will be an entire absence of any purely theoretical discussions. Full reference will be given to the source of the pedigree and to treatises where similar cases are discussed. The Laboratory has already received promises of help from members of the medical profession, and from officials in asylums, sanitoria and hospitals for special diseases. Is it asking too much to beg our Mendelian friends to give us cooperation in this matter, or at any rate to decide on the basis of the first number whether they cannot do so? The need for such a repertorium must be as manifest to them, as to all other students of heredity, and it would add much to the completeness of our scheme if they did not stand aloof from it. The preparation of material for Part I is well advanced and we hope to issue it in October.

K. P.

* Several hundreds of such pedigrees have already reached the Francis Galton Laboratory for National Eugenics.